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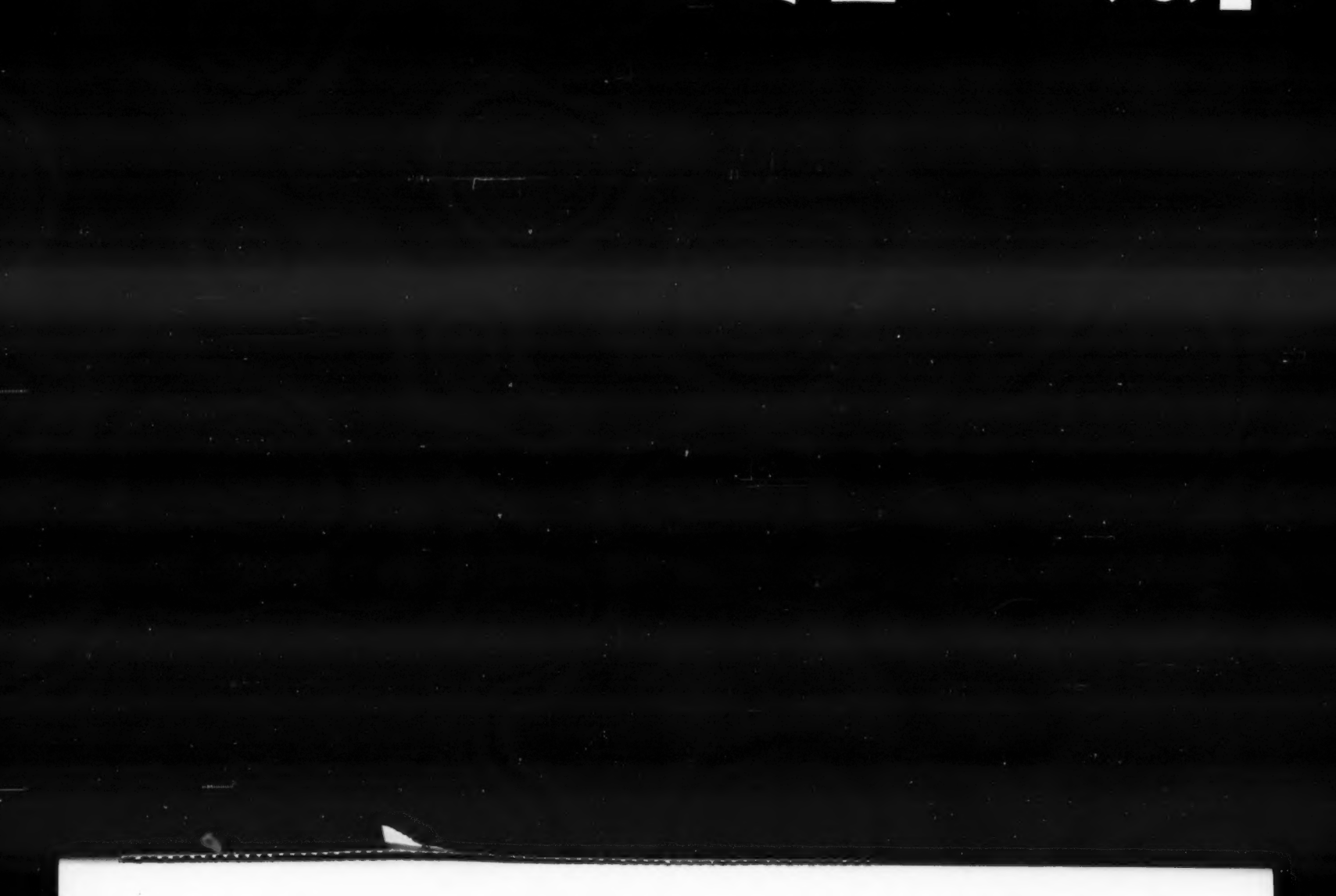

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SCIENCE ADMINISTRATION.—*Pay plans and people.* CRAWFORD R. BUELL, U. S. Post Office Department, Washington, D.C. (Communicated by Waldo L. Schmitt.)

(Received January 6, 1959)

Financial and psychic compensation of scientists and engineers has long posed a dilemma of no small proportions for all government agencies which prosecute engineering and scientific research and development. World events within the past year or two have emphasized the urgency of reaching satisfactory conclusions. Toward this end, the writer, during the past three years, has studied the rank-status concept, giving particular attention to scientists and engineers engaged in research and development. This study developed in some detail the philosophical and historical background of rank-status that had emerged as a concept for civilian employment in the Federal Government in the United States less than 20 years ago. The problems and situations which give rise to consideration of the usefulness of a rank-status philosophy in the administration of research are many. The effect of the administrative climate upon the scientist and, in turn, the attitudes of the scientist and his effect upon that administrative climate are matters that relate to the quality of scientific and engineering achievements that are so necessary in this pre-space age. Some of these elements and situations brought Reimer to the conclusion that, "The futility of the fight against status is gradually being recognized in the Western world and, in certain forms at least, its conscious use is again respectable."[1]

Appraisal of existing techniques used to evaluate positions and to evaluate the people in these positions or applying for them is of especial importance to considerations of rank-status. Considerable attention was given, therefore, to the expressed opinions of groups and of individuals concerning appraisal of these techniques or tools. Evaluation of positions includes job evaluation and position classification. Evaluation of the people includes such aspects of personnel administration as merit rating and qualifications appraisal. From this aspect of the study it was concluded that sophistication of technique does not, by itself, lend validity to any of these techniques. Sophisticated job evaluation and merit-rating techniques may be no more valid and reliable than are some of the less sophisticated tools that frequently are used in rank-status plans.

This paper deals with a specific aspect of rank-status—a comparison of six different pay plans with the Classification Act of 1949, as amended. It is a summarization of what the writer has found to be the methods, techniques, and philosophies used in determining the salary of scientists and research and development engineers in various private and government organizations. It compares the techniques and policies used in six important pay systems or research organizations with those found existing under the Classification Act of 1949, as amended.[2]

[1] REIMER, EVERETT, *Modern personnel management and the Federal service.* The Federal Government Service: Its Character, Prestige, and Problems, Sixth American Assembly, Arden House, p. 161. Graduate School of Business, Columbia University, New York, 1954

[2] Additional material prepared from the notes of the writer concerning these six pay plans, and other aspects of rank-status mentioned earlier, is available from the writer for publication if deemed desirable or to interested students of position classification, pay administration, or research administration.

The term rank-status is used in this paper to indicate systems where rank and pay are based on the person rather than on the position occupied by the person. It is used interchangeably with the terms rank-in-the-person and personal-rank. Rank-status and job evaluation systems each occur in many variations—neither category should be thought of as an absolute. Rank-status is used here to refer to a system where the emphasis is on the *man*, job evaluation to refer to a system where the emphasis is on the position.

Rank-status is a concept which is often misunderstood and which, partly for that reason, has evoked widespread claims, both pro and con, that are as unrealistic as are similar exaggerations concerning job evaluation systems. "The only inherent feature of the rank concept," Stahl has said, "is that status (pay, prestige, rights, etc.) inheres in the individual regardless of the nature of his assignments."[3]

In a rank-status system the various functional areas of personnel administration are oriented toward the man rather than toward the position. Recruitment and selection, and even salary, are based upon the long-range needs of the agency. Recruitment and selection of the individual are based upon the potential of the scientist or engineer rather than upon his immediate usefulness. Hirings and promotions under this concept look toward accomplishing the agency's over-all objectives and goals even though jobs and programs may change from year to year. So too, training emphasizes the next assignment, at least, rather than increased effectiveness in the present assignment. A forester could well characterize rank-status as "viewing the forest instead of the trees," while a social scientist might look upon it as being based on the "inner man" rather than upon the more mundane demands for food, clothing, and a swept-wing motor car. The rank-status concept gives more attention to human relations and less to job relations. It seeks to "oil the inner springs" of man, as someone has said, to motivate the man rather than to emphasize reliance upon organization charts and other mechanistic devices for facilitating the accomplishment of the agency objectives. Rank-status may almost be thought of as a philosophy or a "climate" within which men effectively work toward a common goal, rather than to consider it as a "system."

The study covered selected plans for determining the compensation of scientists and of research and development engineers in the field of mathematics, the physical and biological sciences, and the medical and related sciences. In another sense, it was also a study about people—the people who work under the terms and conditions of those pay systems—and the people of quality whom the Government is seeking to attract to its employment and to retain.

The pay plans which were compared with the Classification Act of 1949 were:

The Los Alamos Scientific Laboratory
The Mellon Institute for Industrial Research
The British Scientific Service
The Public Health Service Commissioned Officer Corps
Public Law 313, 80th Congress, Professional and Scientific Service, Department of Defense
Public Law 692, 81st Congress, Public Health Service

PAY SYSTEMS COMPARED WITH THE CLASSIFICATION ACT OF 1949

I. LOS ALAMOS SCIENTIFIC LABORATORY

The Los Alamos Scientific Laboratory, New Mexico, is an organization of the University of California which performs work under contract for the Atomic Energy Commission. Its personnel policies that have been approved by the Atomic Energy Commission are set forth in each contract. At the time of this writer's visit in 1953, raises of $1,000 or up for persons receiving $12,000 or more per year could be approved by the Los Alamos Field Office, A.E.C., without referral to the Atomic Energy Commission headquarters office in Washington. The plan here discussed covered some 50 senior staff members and 845 staff members.

Under the contracts, salaries paid to persons in the scientific categories must average at the salaries or "salary line" computed

[3] STAHL, O. GLENN, *Public personnel administration* (4th ed.), p. 178. Harper & Brothers, New York, 1950. See also pp. 181, 182, for the first suggestion that the writer has found as to the usefulness of rank-status for scientific research work.

by least squares in terms of "dollars per month" for up to 40 years beyond the last degree granted. This permits hiring applicants either above or below the salary line or exactly on the line if management so chooses. The supervisor is considered to be the person best able to judge the merit of a scientist or engineer and his contribution to the program. "Supervisor" is here used to indicate "levels of supervision" within line management as differentiated from determinations made by staff personnel as to compliance with laws.

The conference of division leaders is the key element in determining what monthly salary will most nearly represent the value of the individual scientist or engineer to the laboratory for that year—all within the frame of reference developed from the annual survey of salaries and in terms of equity with the salaries paid to other staff members. In addition to various "salary line" measures, the personnel office prepares "pictures" of the staff members in useful groupings through the use of mechanical tabulating and other equipment. These background data are then used by line officials in conference in a very informal manner. Part of this process has been described to this writer as:

> The technical organization is sensibly used to provide an upward flow of ideas, feelings, and arguments about the worth of individuals. We are informal, very much so, but we do not operate in a vacuum, nor do we play games with dollars and people.
>
> Very quickly, in such a process of looking at people in terms of similar people, dollar-levels and people levels become apparent; or reverse it if you prefer: certain qualities of persons identify rather precise dollar-levels. The exceptions leap to the eye and demand correction. By slowing down of money to people who are obviously overpaid and the speeding up of money to those underpaid, a "System" starts to be born. The factors are humans. The rating scales are humans. In all of this, administration with a capital "A" supplies information and assistance, maybe an idea now and then, nothing more.[4]

II. MELLON INSTITUTE OF INDUSTRIAL RESEARCH

The Mellon Institute of Industrial Research, Pittsburgh, is an organization of the University of Pittsburgh. At the time that most of the information was obtained it was organized for the purpose of "practical cooperation between Science and Industry." Emphasis has subsequently shifted to fundamental research.

Salary levels for the Institute as a whole were set in a manner somewhat similar to that used at the Los Alamos Scientific Laboratory. The salary lines were based upon annual rather than monthly rates and comparison was based upon the age of the individual rather than on the number of years following the last degree.

Statistics were prepared each year. This included sorting the employees according to degrees held (bachelor, master, and doctor) and then grouping according to the age of the individual. The average salary of each age group was plotted with respect to age, and a straight line drawn to represent approximately the average trend. This line was used simply as a guide and not as a hard and fast rule. The director of research explained that if an individual salary is above or below the line by too great a distance (particularly below), an adjustment is made to minimize the discrepancy. The director, subsequent to his retirement has recently written:

> There are always gross exceptions. But broadly we have judged a man on the character of work that he is doing, his accomplishments, on his personality, his relationship with his donor organization, and of course in later years on the "cost of living." In research, as you know, it is the individual and not the "position" that determines his worth.[5]

III. THE SCIENTIFIC OFFICER CLASS OF THE BRITISH CIVIL SERVICE

The scientific officer class is the highest of the three classes of the scientific civil service of Great Britain. It includes scientists engaged in research, and scientists and engineers engaged in research and development. The fields of work covered are substantially the same as those covered by a large number of occupational specialties which were under the professional service of the Classifictaion Act of 1923 and now are under the Classification Act of 1949. Within the British service, however, the

[4] Personal correspondence from John A. Woodward, wage and salary administrator, Los Alamos Scientific Laboratory, Los Alamos, N. Mex., July 22, 1957.

[5] Personal correspondence from E. Ward Tillotson, July 22, 1957.

scientists and engineers are not "catalogued" either by themselves or by the personnel system into as narrow specialties as is customary in the United States. The Royal Commission on the Civil Service, 1953–55, reported some 3,400 employees in the seven "grades" or "classes," each of which is titled "scientific officer" with an adjective being used to indicate the level.

There are two principles that constitute the major base upon which the salary scales for all British civil servants are built. However, the Royal Commission report stated:

> It seems to us desirable that there should be one set of principles of pay for the whole Service ... But this is not to say that there can be one short formula that can by itself solve all wage and salary problems.[6]

The principle of "fair comparison" (with current remuneration of outside staffs employed on broadly comparable work, taking account of differences in other conditions of service) is the primary principle of pay. The secondary principle is the maintenance of "internal relativities." Internal relativities may be "vertical relativities" between grades within a class or service or may refer to the relationship between classes engaged on the same broad type of work. Internal relativities may also be "horizontal relativities" or comparisons between grades or classes held to be of comparable status or of roughly the same level of responsibility in different hierarchies.

Most of the scientific officer grades have a broad salary range wherein annual promotion is customary and with fixed annual increments. Some of the grades have a "bar" in the middle of the range, beyond which bar the scientific officer cannot pass without affirmative action of a reviewing panel of scientists. Once this action has been taken he can proceed to the top of his grade range by larger annual increments. For the chief scientific officer grade there were two rates of pay adopted, partly because there were sufficient variations between the posts to warrant it (job evaluation) and partly for the advantage if it were necessary to recruit from outside the service. "Posts above chief scientific officer" were "broadbanded" on the span of £3,500–£6,000 per year with no stated intermediate steps.

Specialized posts in the higher grades are occasionally filled from the outside. If the applicant is from industry, the civil service selection board (of scientists) will look at his present salary and may appoint him at one of the higher steps within the class to which he would normally be appointed. It could, if it wished, place him in a higher grade if such action were needed in order to recruit (or retain) a specific individual.[7] The principle of fair comparison makes comparison with industry salaries feasible, even though the government scientific officer salaries were considered by some to be unfavorable compared with industry. In recruiting for the very highest posts, public advertisement is not favored. Instead,

> ...all government and other scientists of the required standing are considered by high level scientists and administrators, working in conjunction with the Civil Service Commission, and the most suitable individual available *would be invited* [italics not in original] to accept the appointment.[8]

It may be noted in passing that the flexibility in determining starting salaries for the two lowest grades is limited to one salary step. This flexibility in determining the starting pay of scientists and engineers accomplishes in a direct manner that which so often is achieved under the Classification Act of 1949 only after a struggle—accomplished sometimes on merit as gauged by job evaluation, but probably more often accomplished either with the connivance of position classification authorities, or by what has been euphemistically called "outwitting" the classification authorities.

Flexibility is also found in another procedure whereby under the "special merit promotion scheme" posts may be created outside the normal organizational hierarchy for outstanding individual research workers. This recognizes the value,

> ...of scientists of marked creative ability whose advancement should not involve any break in their

[6] Royal Commission on the Civil Service, 1953–55, *Report*, p. 23. Her Majesty's Stationery Office, London, 1955, Cmd. 9613.

[7] Personal interview with H. J. Hadow, head of United Kingdom Scientific Mission, July 31, 1957.

[8] Royal Commission, p. 130.

scientific work; in such cases, subject to the recommendation of a high-level selection board, the Treasury may approve promotion on "individual merit."[9]

An unusual characteristic of the British scientific service is that the recruitment, promotion, pay and other personnel processes are each scientist-oriented rather than personnel technician-oriented.

IV. PUBLIC HEALTH SERVICE COMMISSIONED OFFICER CORPS

The Public Health Service Commissioned Officer Corps is composed of some 10 occupational categories. The scientist officer category includes those officers whose primary function is research, although others may also do research to a lesser degree. The research is both basic and applied, and may be performed in the laboratory, in the field, or in clinical situations. Some of the titles carried by the officers include bacteriologist, biochemist, psychologist, physiologist, and protozoologist. There were somewhat more than 200 scientist officers, as of August 1957, of a total corps of close to 6,500.

The corps is a nonmilitary organization of highly trained professional men and women of many occupations. Personnel and pay procedures are the same whether for the scientist officer, the medical officer, or any other category. The corps is made up of officers who typically intend to spend most or all of their working careers in the corps.

The pay system and the pay scales are those of the military forces. Flexibility for pay determination within a stated pay grade does not exist. Judgments about an officer applicant or about the promotability of a scientist officer are typically the result of group judgment of his peers. Usually at least one of those peers is in the same specialty field or the same professional field as the person being judged. Provision exists for "selection out" of the officers who are not considered qualified for promotion by a promotion board.

The organization rates and ranks the man upon his over-all usefulness to the service. This relieves the scientist officer of concern as to whether an individual assignment might result in professional down-grading such as might occur under the Classification Act of 1949 for positions which are subject to that Act. It is the responsibility of the organization to place the scientist officer in such assignments as are appropriate, when possible. Thus rank—and assignments—follow the man.

The rank-in-the-person follows length of service in grade for permanent promotions but it follows more closely the personal ability of the man when it comes to temporary promotions. Pay follows the rank to which the officer is promoted, with the pay grades being the same as for the military.

Although not tied directly to determining annual salary, it is interesting to note that sophisticated systems are used in applicant rating by interview and file evaluation boards and used in performance appraisal and selection for promotion. While it is significant that sophisticated systems are characteristic of this corps, the fact that they are used by typical scientist officers rather than by personnel technicians or administrators may be of equal significance to the corps from the standpoint of morale.[10]

V. PUBLIC LAW 313, 80TH CONGRESS, DEPARTMENT OF DEFENSE

The act of August 1, 1947, usually known as Public Law 313, 80th Congress, established a special pay system for professional and scientific positions which were established to effectuate research and development activities of what were then known as the War Department and the Naval Establishment.

Although World War II fighting had long since ceased, the research and development emphasis of national defense was not fully achieved. Many competent scientists and engineers were resigning from the activities of the Department of Defense (then War and Navy) for more lucrative positions outside of the Federal Government. A one-day hearing on H.R. 4084 brought testimony from less than half a dozen officials, chiefly military, that the work to be assigned em-

[9] McCRENSKY, EDWARD, *Scientists in the British Civil Service*. Science **124**: 569. Sept. 28, 1956.

[10] Basic material on the corps was obtained from the writings of Sidney H. Newman, Ph.D., chief, Officer Selection and Evaluation Program, and interviews with him and with Paul M. Camp, chief, Division of Personnel.

ployees under this proposal was of such scope and responsibility as would normally be assigned to an officer of the rank of general. As to "why not make them generals?" Admiral Hussey replied that the civilian scientists wouldn't stand for it, that they feared military regimentation. The proposed positions were to be established under a procedure "fully in accord" with section 13 of the Classification Act of 1923.[11]

Public Law 313 was a 3-paragraph act which provided simply the following:

1. Each department was authorized to establish fifteen positions in the professional and scientific service, each being established to effectuate research and development functions, and any and all other activities which require specially qualified scientific or professional personnel, provided that the rates of compensation [then $10,000 to $15,000] shall be subject to the approval of the Civil Service Commission.
2. Appointments shall be made without competitive examination upon approval of the proposed appointee's qualifications by the Civil Service Commission *or such officers or agents as it may designate for this purpose*. [It is noted that all decisions have been made within the Commission, no delegation having been made to other agencies.]
3. An annual report to Congress was required, showing names of employees, functions performed, and salaries.

At the time the rest of this statement was prepared, Public Law 313 had been amended to include not more than 120 positions in the Department of Defense, 25 in the National Security Agency, and 30 in the National Advisory Committee for Aeronautics. Due to Public Laws 85-462 (June 20, 1958) and 85-568 (July 29, 1958), the present (January 1959) authorizations under Public Law 313, as amended, are: Department of Defense, 292, National Security Agency, 50; Interior, 5; Agriculture, 5; Health, Education, and Welfare, 5; and Commerce, 25. [In January 1959, in addition to the authorizations of Public Law 313 listed above, there are some 380 other positions authorized under the same general philosophy. These include 85 in the Public Health Service, which are discussed under Public Law 692, and 260 in the National Aeronautics and Space Agency.]

[11] U. S. Congress, House of Representatives, Committee on Post Office and Civil Service, Report to Accompany H.R. 4084, July 16, 1947, House Report 953, 80th Congress, 1st Session, 3 pp. (Not printed.)

The first review of a submission received by the Civil Service Commission (typically received as a "name case") is in terms of the Classification Act of 1949. Is it a scientific or professional position established within the requirements of P.L. 313 and what would be the grade level of the position if it were under the Classification Act of 1949? This preliminary evaluation includes consideration of the following factors:

1. The nature, magnitude, and scope of the agency's research and development program and its relation to the international situation.
2. The career of service and the scientific accomplishments of the incumbent.
3. The approximate comparison as to scope of program and weight of responsibility with other jobs which may be comparable.
4. The nature of the agency's organizational structure.
5. Whether during a transitional period there is an attempt to maintain consistency between the former pay rate and the proposed pay rate in the total range of pay.

The second and fifth items are factors not used in the evaluation of Classification Act positions.

Following this, a comparison is made between the salary recommended by the agency and the GS grade appropriate if it were under the Classification Act. This is done by dividing the P.L. salary range into three subranges approximately equal, each subrange to be roughly the equivalent of one of the three "supergrade" levels, GS-16, 17, and 18. Conformance to this rough guide would result in recommendation by the Personnel Management Review Division that the salary be approved, subject to review of the qualifications of the man by the Examining Division. It is believed that no case has been rejected on the qualifications aspect that had been approved by the position evaluation. Where disparity exists between salary *range* that would appear appropriate from the position review and the salary recommended by the agency, a conference is held with agency officials, seeking additional information concerning the man, the program, or the scarcity of men of the required qualifications. A denial of an agency recommendation would come only after such inquiries had been made. The Commission no longer determines on its own initiative what the appropriate salary is. It

either accepts or rejects the recommendation of the agency. An agency may resubmit a case with a different recommendation if it chooses.

While the Commission studiously avoids taking original action that is the responsibility of the agency, it appears to be equally desirous of avoiding a rubber-stamp role, requiring substantially equal justifications for recommendations of changes of salary downward that it requires on changes upward.[12]

As with super-grades, each military agency has two administrative problems—approval of a Public Law 313 "space" and getting the man for the space. Approval of the space is internal within the Department of Defense, yet the layers of review of proposals may be far more time-consuming and hazardous than obtaining salary and qualification approval from the Commission.

VI. PUBLIC LAW 692, 81ST CONGRESS, PUBLIC HEALTH SERVICE

The Act of August 15, 1950, was identical to Public Law 313 except that it applied to the Public Health Service.

Senate Report No. 1102 described the reasoning back of this pay system that was established outside of the Classification Act of 1949, saying,

> Authority to pay reasonable salaries to outstanding scientific and professional persons engaged in research is essential if the quality as well as the quantity of medical research is to increase.
>
> The full potentialities of the whole research staff of the Public Health Service can be brought out only if those who guide its research activities combine research talents of the highest order with ability to stimulate others and administer large programs. This combination of talents is rare. Persons who possess them command high salaries.

The personnel manual of the Public Health Service contains statements concerning the approving authority, general policy, promotion policy, eligibility criteria for individuals, determination of salary levels, and processing procedures that are unusual in setting forth useful criteria succinctly for all interested parties. The designation of these positions and the determination of salary levels are considered part of the career development program that cannot be met within the commissioned corps or the Classification Act pay systems. The position and the salary will be identified with the incumbent or prospective incumbent and will exist only during the period that the position is occupied by the incumbent. This recognizes administratively the rank-status basis of Public Law 692, rather than considering it merely as an extension of the Classification Act with the "position" concept.

The manual contains criteria for determination of salary levels. There are two general guides that apply to all categories of P.L. 692 personnel, these elements being:

1. An assessment of the demonstrated competence of the candidate, whether applicant or incumbent.
2. The extent to which competition for scarce manpower or other factors tends to raise non-government salaries.

The three categories of personnel each have a separate and additional criterion, as follows:

1. *Independent Investigators*
   - Up to $15,500—may be paid to those who are fully competent, mature and highly productive.
   - Up to $17,500—may be paid to those of exceptional competence with international reputations.
   - Up to $19,000—may be paid to those who are, by general consensus, recognized as fully competent to occupy the most distinguished academic chairs or to assume key research posisions in industrial research.
2. *Clinical Specialties*—may be paid salaries generally comparable, within the $19,000 ceiling, with the total earned income of their counterparts in academic teaching and research posts, but not with the income of those engaged full time in the practice of medicine.
3. *Program Leaders*—the importance and complexity of the position, and the size and complexity of the program for which the incumbent is responsible.

The manual also provides that, in formulating their recommendations, chiefs of bureau as well as chiefs of division may utilize the technical advice of such groups of professional peers or supervisors, of the

[12] Most of the material concerning administration of P.L. 313 within the Commission was obtained in interview with Ralph Remley, chief, Classification Appeals and Special Services Office, U. S. Civil Service Commission, April 2, 1957.

candidate or incumbent as they may determine to be needed.[13]

VII. OTHER SYSTEMS

The Battelle Memorial Institute, Columbus, Ohio, has had a form of rank-status since it was founded in 1929. Its former metallurgist director has said,

> The ideal criterion for personal recompense in any business is *productivity* [italics in original]. The persons who produce the most deserve the most pay ...
>
> ... In modern research this difficulty of measuring productivity is increased many fold.... To take the results of team research and to say that this percentage is creditable to that person's efforts, is to destroy the structure that makes research effective. Consequently, we must use empirical rather than mathematically precise means to evaluate each man's worth. We do this by appraising other qualities of the individual that experience tells us are usually related to his productivity.
>
> These qualities determine the "merit" of the technical man to the research organization, and salary increases based on such evaluation are called merit raises.[14]

Every staff member's situation is reviewed quarterly; there are no standard or automatic increases of any type, and no arbitrary rules for determining the amount of increases, if any, to be given at any one time. These appraisals rely heavily upon evaluation of personal traits. Among these are initiative, willingness to put out some extra effort, tenacity to follow through, and economic "sense" superimposed on the basic technical knowledge required. Other traits evaluated are salesmanship (including report writing—because their only product is the research report—and vocal presentation and interpretations of the user's needs), administrative talent, and, importantly, scientific integrity and selflessness.

The policy at Standard Oil Co. (of New Jersey) apparently recognizes the inadequacy of job evaluation as a basis for pay for research workers. In an answer to an inquiry from the writer concerning rank-status the manager of the Employee Relations Department wrote as follows:

> Job evaluation does not seem to be appropriate to professional engineers and scientists because none of them perform according to a job description. Job classifications are based primarily on traditional relationships between jobs, skills required and responsibility exercised. The professional employee's effectiveness depends on his individual contribution within a team effort. Perhaps a more important factor determining pay is the condition of supply and demand. It sets salaries far more than a job classification. The very large turnover among professional employees in research organizations is an indication of the dominance of economic factors over rigid classification systems.[15]

During the summer of 1957 General Electric was in the process of changing some of its personnel and pay policies, and so was not in a position to discuss plans which it expected would be installed. Bearing upon the goal sought by some persons of having a single pay system for all civilians in the Federal service, the multiplicity of plans within GE is of interest. A consultant with GE has written,

> As a part of our broad decentralization program, substantial latitude is provided for managers of our decentralized departments in establishing the particular practices they believe most appropriate for their particular operations. As a consequence, it is difficult to generalize and develop statements that are truly accurate for the General Electric Co. as a whole. We have, for example, more than 35 position evaluation methods now in use in our Company.[16]

The consultant called attention to the 1957 report of the Defense Advisory Committee on Professional and Technical Compensation, of which Ralph J. Cordiner (president of General Electric) was chairman. The point was made that the report contained statements of some of the basic concepts which are considered, at General Electric, to be important in the development of compensation structures and suitable compensation relationships.

The chart herewith, "Generalized Comparisons Between Various Aspects of Selected Pay Systems," is a summary of some of the comparisons between the seven pay plans given major attention.

[13] Basic material on administration within the bureau was obtained during interview with Paul M. Camp, chief, Division of Personnel, August 15, 1957.

[14] WILLIAMS, CLYDE, *Bases research worker salary structure on merit system*. Industrial Science and Engineering, January 1955: 33.

[15] Personal correspondence, a statement prepared by research people as an attachment to a letter signed in the name of R. L. Mason, manager, Employee Relations Department, Standard Oil Co., New York, N. Y., July 7, 1955.

[16] Personal correspondence from L. L. Ferguson, consultant, Employee Compensation Research, General Electric Co., New York, July 17, 1957.

Pay Plan Aspects	Los Alamos Scientific Laboratory (A)
1. Pay based primarily or entirely on the MAN or on the JOB?	Pay is based on the MAN.
2. Pay geared to accomplishment of long-range or short-range objectives of agencies?	Pay administration is geared to long-rang with considerations of the man's potential achievement at end of, say, next 5 years.
3. Assignments based on pay or rank—or pay or rank based on assignments?	Assignments are based typically on pay of th or engineer. (High quality job performa cause a salary increase? Lack of quality salary stagnation.)
4. Effect of assignment to lower level work.	No effect unless it is permanent or prolonge to lack of competence.
5. Effect of assignment to higher level work.	No immediate effect. Quality of work done n in higher salary from next salary review.
6. Methods of evaluating the MAN. A. Applicant evaluation based on: scholastic history, potential, or work-or-salary history.	*Applicants* are evaluated on basis of educat of degree) and comparison with curve of other S & E's in U. S. for the same numbe beyond last degree earned. Potential is incl
B. Employee evaluation based on: job performance or empirical solutions designed to represent job performance which is considered to be immeasurable directly.	*Employees'* evaluation includes the above, plu tion of last year's work and comparisons w employees.
7. Making of salary determinations or effective recommendations for same: A. As to person or group making them. B. As to extent to which they are made by "peers," i.e., by scientists and engineers (S & E's).	Supervisory scientists initiate the salary reco tions and the division leaders' conferences fective review of these recommendations, th necessarily having the last word.
8. Orientation of salary plan and its administration.	Oriented toward line management. ("Line ment" here is a group composed of the senior or engineers.)

(Note: "Job Evaluation" is used in the general sense of analysis and evaluation of the duties, respons

GENERALIZED COMPARISONS BETWEEN VARIO

(Conclusions based upon study of the systems — in some instan

ntific Laboratory A)	Mellon Institute (B)	British Scientific Service (C)	Pu
	Pay based on the MAN	Pay is based primarily on the MAN, for higher levels. Broad job evaluation is used for most posts in B.S.S. but at the higher levels "scientific officers" may be placed in a higher grade if necessary to recruit from industry or to retain. (Job evaluation for B.S.S. is typically a means of determining posts to which men of specified rank are normally assigned.)	Pay is is n speci tions
red to long-range program man's potential & expected ay, next 5 years.	Apparently it is the same as for Los Alamos although no direct information was obtained.	Pay administration is geared to long-range objectives.	Pay ad
cally on pay of the scientist ity job performance may Lack of quality may cause	Same as Los Alamos.	Assignments are based typically on rank of the scientific officer. Occasionally for higher posts it will be reversed and "spot" promotions used.	Assignm tist o to a f self.
nent or prolonged and due	Same as Los Alamos.	Assignments to lower level work typically have no effect on pay or on future assignments.	Assignm reduc ticed indivi
y of work done may result salary review.	Same as Los Alamos.	Assignments to higher level work have no immediate effect. Level and quality of work would be considered by next promotion or selection board (for promotions to 2d and 3d levels "without waiting for a vacancy," or for promotion to "individual merit" positions).	No imm consi
n basis of education (kind n with curve of salaries of the same number of years . Potential is included.	Essentially the same as for Los Alamos, except (1) salary history is based on age rather than on years since last degree, and (2) the acceptability to (or relationship to) the donor organization in regard to salary.	*Applicants* are evaluated, for entrance to lowest grades, on basis of review of scholastic honors (univ. degree with 1st or 2d class honors required) & on potential for growth, by means of oral & written exams & reference checks. For higher levels, graduate work, acceptable work history, & salary history are used, including industry pay. *Employees* are evaluated on basis of record obtained when applicants, plus annual job performance evaluation A and B, seek to determine the man's stage in growth.	*Applica* fessio backg visor oral & *Employ* choice attitu used
es the above, plus evalua- d comparisons with other			
e the salary recommenda- ders' conferences make ef- mmendations, though not word.	Salary recommendations and determinations were made by persons who were scientists or engineers. It is not known whether group action was used in making the determinations.	Salary recommendations (usually tantamount to determinations) are made by panels of senior scientists which have some leeway in determining starting pay at lowest two levels & may authorize placing an applicant from industry, or an employee, in higher grade if necessary to attract or retain in B.S.S. May promote to special merit posts (subject to Treasury approval).	Group tions. tist of cant; worke board selecti
gement. ("Line Manage- osed of the senior scientists	Same as Los Alamos.	To a considerable degree it is oriented toward line management scientists and engineers. In addition, the job evaluation used in part does not have the degree of orientation toward the personnel technician that is found in the Classification Act of 1949.	Oriente comm some

e duties, responsibilities, and qualifications required for minimum satisfactory performance required by a position).

TWEEN VARIOUS ASPECTS OF SELECTED PAY SYSTEMS

n some instances based upon inference rather than specific facts found)

	Public Health Service Commissioned Officer Corps (D)	Classification Act of 1949 as Amended (E)	
levels. B.S.S. may be rom in- s typi- of spec-	Pay is based primarily on the MAN. A job evaluation plan is not used, although some specific higher posts carry specified ranks & may be filled through "spot" promotions.	Pay is based on the JOB. Job evaluation plan is based on duties, responsibilities and qualifications required. It is used to place the position in a "class" to which is attached a specific pay range.	
ives.	Pay administration is geared to long-range objectives.	Pay administration within D.O.D. agencies is geared to short-range objectives—to the immediate job to be done.	
ientific eversed	Assignments are based typically on rank held by "scientist officers." However, rank and pay of those assigned to a few "restricted" positions are based on the job itself.	Pay is based on assignments which have been evaluated by job evaluation & assigned to a class (including grade level). "Details" (supposedly of short duration) involve no change in pay.	
o effect	Assignments to lower-level work would not be the cause of reduction in rank or pay. Career management is practiced—it relieves the man of concern as to whether an individual assignment might harm his pay or career.	Grade and pay are lowered if found on survey or job audit—unless management is given opportunity to reassign duties or employees. Pay is not lowered in a few "savings" cases provided for in the Act.	
iate ef- ered by s to 2d " or for	No immediate effect. Level and quality of work would be considered by next selection board.	Grade and pay would be raised if the S & E is legally qualified for such grade.	
grades, degree otential & refer- accept- cluding	*Applicants* for first 2 levels always are given written professional exam, an oral interview, a file exam (entire background, education, training, & experience, & supervisor & teacher reference checks). For full grade & above, oral & written exams may be waived.	NOT APPLICABLE: Neither (A) nor (B) is applicable, because the position is evaluated separately from the MAN.	
d when tion A vth.	*Employees* are evaluated annually on job proficiency, forced choice rating by worker-associates, & measures of work attitudes & job performance items. Selection boards are used for promotions & selection-out.		
etermi- which lowest t from cessary special	Group evaluations are used for pay & tenure determinations. Some or all of applicant-interview panel of scientist officers are in same professional category as the applicant; file evaluation board members are scientist officers; worker-associates ratings are by "peers"; investigation boards must contain one member of same profession; selection board is also a "peers" group.	Positions of S & E's typically are classified in agencies by position classifiers (who are not also S & E's unless by chance) or by administrative or personnel officials on classifier recommendations. Group evaluation is seldom used (P.H.S. uses). For supergrade S & E positions, C.S.C. commissioners have lately delegated their authority to C.S.C. classifiers.	
anage- ob eval- orienta- d in the	Oriented toward line management which here is that of commissioned officers of whom some are scientists and some are engineers.	Oriented toward one specialty of personnel technician—the position classifier.	

Amended	Public Law 313 (D.O.D. Agencies) (F)	Public Law 692 (Public Health Service) (G)
ion plan is based cations required. "class" to which	Pay consideration in agencies of D.O.D. varies. It may be either based on the MAN or the JOB. C.S.C. determination is based primarily on JOB—with the MAN's qualifications sometimes influencing doubtful cases.	Pay consideration in P.H.S. is usually based on the MAN. C.S.C. determination is same as for P.L. 313.
ncies is geared to ediate job to be	Pay administration within D.O.D. agencies is geared usually to long-range objectives; within C.S.C. it is geared to the immediate job to be done.	Pay administration within P.H.S. is geared to long-range objectives as part of a career development program that can not be achieved under P.H.S. Commissioned Officer Corps or under Classification Act. Within C.S.C. it is geared to the immediate job, as is case with P.L. 313.
e been evaluated class (including of short dura-	C.S.C. typically bases pay upon assignments. Once this has been done, agencies typically assign S & E's upon the basis of salary and ability. (See 3. E. concerning "details.")	Same as for P.L. 313.
n survey or job opportunity to not lowered in a the Act.	There is no known effect if assigned to lower-level work except that if it appeared in position descriptions or certifications required periodically by C.S.C. it would presumably affect pay adversely. Management may initiate action.	Same as for P.L. 313.
S & E is legally	If duties are to remain of a higher level, presumably the agency would request review by C.S.C. and a higher salary. C.S.C. would not initiate it.	Same as for P.L. 313.
or (B) is applied separately	C.S.C. evaluation of *applicant* is based on S.F. 57, Application for Federal Employment, plus agency letter of transmittal—sometimes supplemented by additional information from applicant, or from "American Men of Science," etc. Agency & D.O.D. evaluations vary greatly as to kind. Same as above, if not already in the file.	C.S.C. evaluation of *applicant* is same as for P.L. 313. P.H.S. *recommendations* are made initially by chiefs of bureaus or divisions (professional men) who are encouraged to use the technical advice of groups of "peers" or of supervisors as needed. All line officials over a P.L. 692 man are professional. Action in Dept. of Health, Education, & Welfare was not learned. Same as above.
ified in agencies o S & E's unless rsonnel officials p evaluation is grade S & E pately delegated	Effective recommendations are made by position classifier (if more than one, the others are reviewers). Final determinations are made by the Commissioners as a group. No one in C.S.C. is a practicing scientist or engineer. None who pass on these matters would have been so trained, unless by chance.	C.S.C. recommendations & determinations are made same as for P.L. 313. (Note that in C.S.C. a group—commissioners—*acts on recommendations of an individual position classifier review* of the agency recommendation. In P.H.S. a line official (professional) frequently *acts upon a recommendation of a group of professional peers.*)
nel technician—	The total system partakes both of orientation toward position classifiers and, in some agencies, of orientation toward administrative or military personnel (rather seldom oriented toward scientists and engineers).	The system is oriented toward position classifiers and administrators at the C.S.C. level; and to professional personnel (including scientists and engineers) at the P.H.S. level.

CONCLUSIONS AND RECOMMENDATIONS

The facts and opinions assembled during this study furnished convincing evidence that categorical and sweeping generalizations on the subject of rank-status for scientists and engineers would be hazardous. They might be as unsound as the chant, "Four legs good, two legs bad," used by some of George Orwell's animal characters as a means of differentiating the "good" animals from the "bad" humans in his *Life on the animal farm*. In one sense, rank-status may be considered to be almost a philosophy or a symbol of principle rather than necessarily a pay plan.

Aside from the Classification Act of 1949, as amended, all the pay plans studied in detail represent, to this writer, variations of rank-status pay plans. The matters of principal interest in this study are the variations in the degree to which pay is based upon the qualifications of the man or upon the production of the *man* rather than the duties and responsibilities of the *position*.

Although there is a common philosophic approach to the problem of pay, in practice there are restrictions of one kind or another which result in a variety of methods used. On the other hand, the Classification Act of 1949, as amended, which furnished the point of departure for the study was the single strictly job evaluation plan that was studied. More scientists and engineers in research and development are paid under the Classification Act of 1949 than under any other pay system. It is useful, therefore, as a specific against which to compare other systems. But to consider the Classification Act as being "THE" job evaluation plan and representative of industrial job evaluation plans would be grossly misleading. Industrial plans for job evaluation not infrequently include evaluations of the contributions made by the individual as well as evaluations of the duties and responsibilities that are assigned by management and of the working conditions as they are found to exist. An example of such a composite plan for evaluating creative engineers has been described by Chaffee.[17] In addition to the duties and responsibilities of a position that would be measured under the procedures used in organizations whose positions are under the Classification Act of 1949, numerous personal qualities would be measured, as would job performance. The total evaluation, if scored high enough, would place the incumbent in a merit subgrade. This technique is in accord with the more generalized proposal of the Purvis committee for premium salary "which will give recognition to the skills and abilities brought to the job by the individual . . . over and above job evaluation techniques now used to determine an incumbent's grade and pay."[18]

This study may be considered to be a comparison between one specific type of job evaluation plan (the Classification Act of 1949, as amended) and several other pay plans, each of which has some of the "flavor" of rank-status.

SUMMARY OF CONCLUSIONS

1. *Conclusion: Research and development personnel is an unusually rapid growing occupational group in the work population of the United States today, yet it is in short-supply when considered against current needs—especially as the needs relate to the defense of the nation.* This group, with its high professional standards and working habits and with a different kind of logic from that characteristic of nonprofessional personnel, has attitudes that are hostile to many aspects of administration. Personnel administration as it has been practiced *on* them is typically anathema. Salary and prestige associated with their professional attainments mean much to scientists and engineers—although not to the exclusion of adequate salary. The "social handles of the pay cup" concept which emphasizes the social aspects or prestige that follows the pay itself is important to scientists and engineers, although apparently not to the extent found by Whiting a quarter-century ago in his study of laboring groups.

Because of a combination of salary prob-

[17] CHAFFEE, RANDOLPH W., *Evaluating engineers to recognize talent and reward achievement*. Machine Design, June 1951: 143–172.

[18] U. S. Congress, Senate Committee on Post Office and Civil Service, *Administration of the Classification Act of 1949 and the compensation process established by the act*, Senate Document 34. 83d Congress, 1st Session, p. 22. 1953.

lems (e.g., comparisons with the trades and crafts) and lack of attention by management to status and recognition for their work, scientists and engineers are either "on the move" or at least are preconditioned to accepting an offer of employment from another organization. Absurdities and extremes have existed in the use of status and prestige symbols, ranging from the kind of carafe available to an executive, to parking lot privileges, to priorities in obtaining Asiatic flu vaccine, and to other more tangible rewards. The fact that absurdities have existed has not blinded many organizations to the value of a reasoned use of status and prestige. The conscious use of status in the Western world is again becoming respectable. It will probably become increasingly recognized now that the launching of the Russian "sputnik" as the first earth satellite has caused additional attention to be focused, perhaps belatedly, upon the problems of training, recruiting, and retaining an adequate supply of quality scientists and engineers.

2. *Conclusion: Different principles and practices in personnel administration are needed for scientists and engineers in research and development than for persons in other occupations and functions.* Scientists and engineers do not usually fit into the administrative process either by personal traits or by process or function. "Supervision" is a term that is anathema to them, particularly so the closer one gets to basic or "pure" research or to the higher levels of research and development. Especially in these areas the organizational structure tends to emphasize the man rather than the position. Personnel administration as developed by personnel administrators who are not scientists or engineers is especially obnoxious to them—they object to having such personnel administration "applied *to* them." Because of these things, administrators attempt to adjust both the substantive work organization and the facilitative organizations to conform to the needs of the personnel who are to accomplish the mission of the work organization. In the facilitating organizations which are responsible for the personnel administration function this is most noticeable in the reduction in procedures and in the use of "committees of peers" for decisions in the personnel areas. As Boehm quoted a research director, "Research can be managed in a businesslike way, but not in a way like other business."[19]

3. *Conclusion: The subject of rank-status or rank-in-the-person has been discussed for only about two decades in the United States but neither the concept nor the application is of recent origin.* Extensive application of the concept existed in the government of China during the early centuries of the Christian Era. In the Western world it appeared in the military, in the Catholic Church, in the civilian governmental organizations of European and other areas, and in United Nations organizations before consideration for use in civilian government situations in the United States. Beginning with the proposal by Graham in 1939, the subject has come to be increasingly in the public eye as a result of recommendations of congressional and presidential committees, and the writings and speeches of public-spirited groups and individuals from many walks of life who have broad knowledge of public affairs. Among the groups which have favored emphasis upon rank-status or at least further study of the usefulness of rank-status to the Federal Service are: the Advisory Committee on Natural Scientists (1942), the Senate Committee on Post Office and Civil Service (1953, Purvis Committee), the Commission on Organization of the Executive Branch of the Government (1955) (the second Hoover Commission), the Sixth American Assembly (1954), the Society for Personnel Administration (1955), and the Defense Advisory Committee on Professional and Technical Compensation (1957, Cordiner Committee). Some of these groups were studying government as a whole, while others concerned themselves specifically with the work of scientists and engineers or with administrative personnel.

4. *Conclusion: In research and development the degree of development of the scientists and engineers may be of more importance than their precise duties or the particular work assignments by their super-*

[19] BOEHM, GEORGE A. A., *Research management: The new executive job.* Fortune **54**(4): 222. October 1957.

visors. This is signally the case in basic research done by an individual or by the team approach to either research or development. Assignments to a scientist, especially, may be couched in the most general terms. They may sometimes only name the area of study that management is interested in. In other instances, a general outline of study that is defined by management may be deviated from to a high degree because of the scientist's findings or because of lack of specific findings at intermediate points. Deviations may also occur because of "fringe thoughts" —random thoughts that have come to the scientist, seemingly "out of the blue," as a result of his lifetime of preparation in college or university plus the complex of his later experience. The work assignment to two scientists or engineers may be the same, especially under the team approach, but the contributions of an Einstein may be far different from the contributions of a John Doe, Ph.D. Classification of a research and development position independent of an examination of an individual's qualifications and potential has been referred to, with some justification, as an absurdity, and classification without regard to performance as nonsensical.

5. *Conclusion: The job evaluation or position classification concept that "if work (duties and responsibilities) can be assigned it can be described and can be evaluated" falls short of realization for research and development positions.*

This is either the conclusion or the general implication of Graham (1939), Steelman (1947), the Senate Committee on Post Office and Civil Service (the Purvis Committee—1953), the Chief, Bureau of Ordnance, Department of the Navy (1949), Wengert (relating to job evaluation systems in general—1950), Renzetti (1952), and various technical directors of research. Others who have also held similar opinions include Mason (1955), Clyde Williams (1955), and the Defense Advisory Committee (the Cordiner Committee—1957).

6. *Conclusion: Job evaluation plans (including the Classification Act of 1949) are typically unsatisfactory tools with which to determine the salary of scientists and engineers in research and development.* Measuring the duties and responsibilities of scientists and engineers by job evaluation techniques is difficult in itself and, when obtained, often does not measure the value to the organization of the scientist or engineer. One of the reasons for this is that job evaluation plans used in the Federal Government, at least, are not designed to evaluate the effect of the man. In research and development the abilities of the scientist or engineer so often have greater effect upon his contribution to the research program than do the assignments of work and responsibility made by the supervisor.

It is difficult to evaluate scientific and engineering research and development positions and to evaluate the qualifications and the abilities of the scientists and engineers themselves. It appears to be equally difficult to appraise the value of the work product of such scientists and engineers either when engaged in individual research or team research. It is difficult for scientists and engineers themselves to make these evaluations even if they are research and development administrators in charge of the total work operations. It is still more difficult in many of those areas for a person to make valid evaluations if he is not a scientist or engineer.

There has been much criticism of the Classification Act of 1949, as amended, as a tool for measuring the difficulty and responsibility of positions—of work assignments made to scientists and engineers. There has also been criticism that the Classification Act is designed to measure only the difficulty and responsibility of positions with the objective of achieving "equal pay for equal work," whereas what should be measured is the total contribution *of a man* to the research and development program in which he is engaged. There also has been much criticism of various systems used to appraise the worth of individuals, whether in meeting the qualification requirements of the Civil Service Commission for appointment or promotion or in the area of performance appraisal. Particular criticisms and cautions have been voiced against placing too much reliance upon systems which use techniques which involve numeric treatment or obtain results which in some other

way have an aura of exactness that is misleading.

It would be hazardous to believe that either simplicity or sophistication in evaluation techniques is, by itself, either desirable or useful. Rules of thumb in these areas would produce serious inequities as may complicated systems, which produce "reliable" though "invalid" results. So-called "objective" systems (which frequently are also sophisticated) are subject to the same possibility of creating false illusions of accuracy in measuring what they purport to measure.

Job evaluation techniques and man evaluation techniques have been developed in some few situations that afford promise of much greater usefulness than is characteristic of the Classification Act, for example. Typically, however, *reliance on any technique to the exclusion of the considered judgment of operating personnel would be unduly optimistic at this time.*

7. *Conclusion: The present inadequacies of many sophisticated job evaluation plans and man evaluation plans and the criticism that results from such inadequacies emphasize the need for much additional research and development in these areas of personnel administration.* The fact that many techniques fall far short of what is desirable in measuring either research and development positions or in measuring the scientists and engineers themselves should not lead to the conclusion that these decisions should in the future be made as snap judgments or made by intuitions without an array of information available to the authority who is to make the decisions. In the Los Alamos Scientific Laboratory and the Mellon Institute much material is gathered for the authorities who recommend or determine what the salaries will be for the individual scientists, but so far as the actual evaluation of Scientist John Doe is concerned the processes that are used are unsophisticated. On the other hand, some of the evaluation techniques used within the Public Health Service are sophisticated. In each of these organizations and in the British scientific service the techniques used are planned as *aids to* an evaluation by man—not as a substitute for man's judgment. On this point Worthy and Urwick each considered that the various measures of the objective and sophisticated varieties could be very useful to the executive, but that they would be used to "sharpen his judgment" rather than replace it.

8. *Conclusion: The Classification Act of 1949, as amended, appears to be more criticized for positions of scientists and engineers in research and development than for positions in other fields of work.* The criticism in this area comes from employees and management alike. It was found, however, that serious criticism of the Classification Act was not universal, for in some cases there was found the belief that the administration of the Act was more to be criticized than the Classification Act itself.

9. *Conclusion: Rank-status pay plans for scientists and engineers recognize* (1) *the unsuitability of the usual job or position evaluation techniques to research and development work, and* (2) *the antagonism of research and development scientists and engineers to a job evaluation form of administrative stricture with its concomitant lack of recognition for personal contributions.* Part of the unsuitability stems from the previous conclusion which emphasizes the development of the man rather than the job assignment. This suggestion by Graham in 1939 was corroborated by the Advisory Committee on Natural Scientists which looked on the caliber of the job as being a reflection of the man *in* the job and that the classification should rest upon the research contribution of each man. The unsuitability question was again raised in 1947 by Steelman—unsuitability both as to present classification principles and classification techniques for many research and development positions. Renzetti differentiated between the degree of unsuitability or suitability of the Classification Act for research work as compared with nonresearch engineering work which lends itself to a pyramidal structure. The Purvis Committee cited Einstein as an example of a man to whom application of the Classification Act of 1949 would be unsuitable. Basing the salary on the position tends to ignore the contribution of a gifted engineer, in the view of Nicholson.[20] The survey of scientists and engineers

[20] NICHOLSON, SCOTT, *How much is an R/D boss worth?* Research and Engineering, December 1956: 6.

in research and development made by the Department of the Army indicated that scientists and engineers in research and development do not fall into the "readily identifiable levels" that are envisioned by the Classification Act and that the precise duties should not be the sole measure of value of the individual. Adding weight to the conclusions as to unsuitability and antagonism is the fact that the Committee on Scientists and Engineers for Federal Government Programs found that nine out of ten scientists and engineers considered that pay should reflect substantial differences in quality of work performed, something not permitted by the Classification Act or by many other job evaluation systems.

In arriving at his conclusion, the writer was not unmindful that Chaffee attributed to mental laziness and the lack of an organized demand the fact that job evaluation had not (by 1950) really developed for creative engineering, though Chaffee's own work indicated the technical feasibility of such application of job evaluation. So also Sykes, who saw merit in each of the two concepts and appeared to lean toward the Classification Act for areas he had considered.

10. *Conclusion: Rank-status should not carry the connotation of "unlimited license for administrative indiscretion."* It should not be thought of as the discredited system that was not uncommon at the turn of the century which saw the owner-manager's son "start at the bottom and rise to the top" in three or four years. In each of the plans studied there was some form of control over the exact salary to be paid to an individual scientist or engineer. Pay at a stated number of years beyond his last degree was found to be used as a guide for individual salaries at the Mellon Institute of Industrial Research and as a control measure for total salary expenditures at the Los Alamos Scientific Laboratory.[21] At the latter laboratory, since it was engaged on government work, there was also a review control exercised by the Atomic Energy Commission to see that individual salaries did not become absurd. The British scientific service, operating under the principle of "fair comparison" with industry pay for comparable work, has controls upon salary decisions made by agency boards and officials through two means. The first is the existence of salary standards with Civil Service Commission review and approval of entrance salaries above the normal rate. The second is the Treasury review and approval of recommendations for special merit promotions of outstanding individual workers. The scientist officer class of the Public Health Service commissioned officer corps has over-all controls established in congressional legislation and comparable to the military pay system. Its uniqueness stems from the effectiveness of the sophisticated modern techniques used in evaluating personnel for appointment, promotion, and selection-out, and from the fact that the techniques are used by other scientist officers—sometimes in board actions where other members of the board may be from commissioned officer classes other than the scientist officer class.

In the Department of Defense and in the Public Health Service strong accent upon rank-status exists in determining the salaries of those scientists and engineers whose positions come within the purview of Public Law 313, 80th Congress (1947), and Public Law 692, 81st Congress (1950), respectively. With initial control invested in the operating agencies, the Civil Service Commission has review authority over the particular salary to be paid to an individual, including the final determination by that body as to the qualifications of an incumbent or proposed incumbent of a specific position. These public laws were approved with the intention that they would be "in accord with" the compensation schedules of the Classification Act of 1923, as amended, specifically with section 13 which described the then existing grade levels and which prescribed the pay rates for those grades. Although the preliminary review within the Civil Service Commission considers the grade in which the position would be placed, were it under the Classification Act, the ultimate decision of approval or denial of the agency recommendation is based typically on the Commission review of matching the qualifications of the individual with the assigned duties and responsibilities.

[21] Pay at stated ages used at Mellon Institute.

It was learned that in the Canadian civil service the technique for determining the salary of scientists and engineers is a position classification plan but that the control exercised by Treasury is flexible enough to permit it granting salaries above the stated range of salaries for the classification of the position when there are exceptional circumstances.[22] Another recent step toward the principle of recognition of the man in the job, rather than the job alone, was the setting up of some 300 different titles into three classes for the purpose of achieving greater flexibility of personnel and to enable a man to receive the salary that he is worth without always relating his job to a particular classification.[23]

11. *Conclusion: The concept of rank-status or rank-in-the-person—rather than rank-in-the-position—is used successfully as the basis for salaries of scientists and engineers in the organizations of high repute which were studied.* In nongovernmental organizations such as the Los Alamos Scientific Laboratory and the Mellon Institute of Industrial Research and the Battelle Memorial Institute rank-status has been the basis for pay plans that have been used effectively for many years. The British scientific service is based upon this principle as part of its integrated career service. The Public Health Service Commissioned Officer Corps used many of the principles of rank-status, though the specific salaries paid are within the framework of the military pay schedules. Both Public Law 313 positions and Public Law 692 positions have principles of rank-status firmly imbedded in the basic law. The Classification Act of 1949, as amended, is still basically the Classification Act of 1923 with respect to the principle under study. It disregards the qualifications of the "person" except insofar as they are requirements for minimum satisfactory performance of the work described for the "position." No account is taken of unusual qualifications of a scientist or engineer for the position which he is filling.

[22] Personal interview with David M. Watters, Secretary of the Treasury Board, Department of Finance, Ottawa, Canada, May 6, 1957.

[23] Personal correspondence from David M. Watters, October 16, 1957.

12. *Conclusion: A significant practice that was found in most of the rank-status type pay plans for scientists and engineers that were studied was an "evaluation by one's peers."* This practice was found frequently in some form of group appraisal of the scientist or engineer as one of the techniques used in achieving a final determination as to compensation. Although the evaluation methods varied greatly in the degree of sophistication of the process, the significance probably lay as much in the psychological value of the evaluation by one's peers as in the technical results.

13. *Conclusion: Sophisticated systems for evaluating men and jobs are useful to management but should supplement, rather than be a substitute for, the considered judgment of responsible research and development administrators.* Sophisticated systems of job evaluation (e.g., the Classification Act of 1949) are of relatively greater use at the lower levels of scientific and creative engineering work than for the higher levels and they are progressively of less use the more the work proceeds from the routinized or regularized toward the unknown. As Worthy has succinctly expressed it, when referring to executives, rather than to scientists or engineers, "As to methods of determining a man's contribution, I think there is no substitute for executive judgment." And as to measure of the men themselves, "... techniques of this kind [test batteries] cannot be used in isolation nor as a substitution for executive judgment. They can, however, be an excellent means for helping sharpen executive judgment."[24]

14. *Conclusion: Scientists and engineers generally favor having their salaries include considerations of their individual backgrounds of education and training and their contributions to the program.* They are particularly antagonistic toward the practice of having their pay based solely upon a position description—in part because the description so often bears relatively little resemblance to what the incumbent actually does or what he must actually know.

15. *Conclusion: Scientists and engineers*

[24] Personal correspondence from James C. Worthy, March 19, 1957.

usually favor having their contributions to the research and development programs judged by persons with generally the same backgrounds as they themselves have. Scientists and engineers usually believe that a person who is untrained in a particular field of knowledge or work cannot classify positions in that area as well as if he were trained in that work area. As in other controversial matters, there are extreme opinions on both sides of the question. A view frequently held was described in the report of the Committee on Engineers and Scientists for Federal Government Programs as, substantially, that eleven out of twelve Federal scientists and engineers believed that a person could not classify satisfactorily jobs in a professional field unless he were trained in that field. When scientists evaluate scientists they frequently have their own particular disciplines represented. This is found in the provisions of the Public Health Service Manual for the use of the advice of groups of peers in the making of recommendations for the appointments and salaries of scientists under Public Law 692. It is also found in the interview boards used in the Public Health Commissioned Officer Corps and in the panels for fellowship awards by the American Academy of Science.

16. *Conclusion: Rank-status pay plans are more acceptable to management than is the Classification Act of 1949, as amended,* even though controls in the use of rank-status practices are exercised by some level above the laboratory or office concerned. The various writings examined and testimony read indicated to the writer that it is now quite generally recognized that in Government, as well as in most industrial situations, there are few persons, indeed, who make unreviewed and unreviewable decisions in regard to salary and status matters.

17. *Conclusion: The Classification Act of 1949 and its administration often exert a degree of domination over the legitimate needs and desires of management to the extent that operating officials resort to unethical practices in an attempt to escape such domination.* Along with the growth of "scientific management" during the 1920's came the dependence upon classification specialists for carrying out most of the administration of the Classification Acts of 1923 and 1949. Management rather willingly abdicated to what has become an "elite corps of classifiers,"[25] to use the characterization of the Cordiner Committee. Emphasizing mechanics and process rather than the people in the position, the administration of the Act gradually resulted in a separateness from line management of the process and the classification personnel which in some cases was absolute. Position classifiers either made final grade level decisions themselves or served as staff to another staff man, rather than to line management. They were "on top" rather than "on tap" as staff assistance to line management. This dominance appears to the writer to have reached full-flowering in the Federal Government about the end of the Korean conflict.

It frequently happens that an administrator can not increase the salary of a scientist or engineer whose position is under the Classification Act unless he can "rewrite" a position description that will get a higher classification. Because of this, the administrator may covertly or overtly encourage distortions in descriptions of duties. A contest between an administrator's skill at writing descriptions and a classifier's skill in ferreting out the facts through work audits often results in disharmony that injures both the work program and the classification program. Even when harmony persists there may be intense distrust on each "side." Under such situations, position descriptions may degenerate into "job sheets" which are merely exercises in dissimulation. It is not unusual, therefore, to find that the "job sheets" are not believed either by the man who wrote them or by those who read them.

In this connection it is recognized that there is often a broad "zone" within which it is difficult to determine whether the exaggerations and misleading statements of many position descriptions are not only un-

[25] Defense Advisory Committee on Professional and Technical Compensation, Civilian Personnel. Vol. 2 of "A Plan of Action to Attract and Retain Professional, Technical, and Managerial Employees for Defense." Tab. J of Vol. 2 (of Vol. 2), "Problems of Salary Administration Under the Classification Act," by Study Group II, p. 3. Washington, 1957.

ethical practices but are also illegal practices of falsification of a Government pay record.

The writer has concluded that if administrators and employees together resort to unethical practices, the position classifier can usually only delay the action sought by the administrator but can seldom prevent the action from eventually taking place—even though it takes a paper reorganization to accomplish it.

RECOMMENDATIONS

1. The present importance of attracting and retaining qualified scientists and engineers in research and development calls for the utmost in Congressional leadership in authorizing the use of rank-status plans. It also calls for the utmost in administrative leadership and skill in developing and administering one or more rank-status pay plans for the higher level scientists and engineers that will be acceptable to the scientist and engineer and to management. Such plans must meet the American philosophy of pay based upon what the employee is worth to the government organization which hires him. The "worth" of a scientist or engineer should be viewed as the contribution toward the end result or program accomplishment rather than as "equal amount of work" or "equal assignments."

2. The Civil Service Commission should encourage agencies to make more of the agency classification decisions (for positions under the Classification Act of 1949) at top levels of line management rather than in the personnel staff office. The emphasis should be on extensive and intensive use of personnel administrators and technicians as consultants participating in the discussions leading to line management decisions. The Commission should also give added stimulus to constructive interpretation by scientists and engineers of the Classification Act of 1949, as amended, both in development of sound classification standards and in the application of those standards.

3. Legislation should be sought which would:

a. Provide for a Research and Development Corps, outside of the existing Classification Act, in which would be placed the positions of scientists and engineers engaged in research and development, which are now under Public Laws 313 and 692 or which are under the Classification Act of 1949, as amended, at levels above grade GS-15, the pay schedule of this corps to have a minimum and a maximum rate that are at least as high as those currently existing under Public Law 313, but to have no specified pay steps within the range. Provision should be made that positions not initially to be placed under this corps would be eligible for such status upon review and approval by the Civil Service Commission that each position so recommended by an agency was above the level that is characteristic of grade GS-15 under the Classification Act of 1949. It is proposed that there be no statutory ceiling placed upon the numbers of such additional positions.

A case could be made for inclusion of all levels of professional scientists and engineers in the proposed corps.[26] Initial limitation, however, is believed to be more useful, through inclusion of only those whose salaries are above the salaries of the equivalent of GS-15. The proposed corps would thus cover the levels where rank-status is most needed from the standpoint of salary determination. These same levels are where recruitment and retention of the highest caliber personnel would be the most profitable in terms of the personal contributions of the scientists and engineers to the substantive aspects of research and development programs and of their effect as lodestones in drawing junior scientists and engineers of promise into government organizations. This limitation would reduce some of the serious criticisms that would come from employees in other occupations whose pay would continue to be fixed under the Classification Act of 1949, and from other interested parties such as Members of Congress, the Civil Service Commission, and others who would resist any attempt to remove such a large group of positions from the operation of the Classification Act.

[26] See particularly BELSLEY, G. LYLE, *Notes for the Hoover Commission Personnel Task Force on subject of rank-in-the-person* (written presentation to the task force dated March 5, 1954), pp. 2, 3. (Typewritten.)

b. Place the determination of salary levels for individual positions of the Research and Development Corps upon the executive department or agency authorized to have such positions. The agency should be required to file with the Civil Service Commission a plan of administration of this program which would utilize the concept of a board of professional scientists and engineers to make individual salary determinations or recommendations to the head of the agency. Provision should also be made for agencies to change their plans when they see fit, and to file the revised plan or a new plan with the Commission within 30 days after adoption.

The determinations as to salary for an individual should not be subject to disapproval or change by any authority outside the agency. As part of the salary determination process under the professional peer concept proposed, provision could be made for nonvoting participation by a representative of the Civil Service Commission. This representative could be required to file with the agency head any disagreement with a salary decision of the board. The agency also might well be required to transmit such statements to an appropriate committee of the Congress annually, with agency comments, if the agency chooses to make any. So also, the Civil Service Commission could be required to make annual reports to the same committee concerning its findings as to over-all administration of the plan by agencies that are operating under it.

c. Reduce the number of grades of the Classification Act of 1949 to provide for greater rate ranges within the grades to which positions of the scientists and engineers in research and development would be assigned if not coming within the purview of the Research and Development Corps pay schedule. Theoretically this would cover the levels from the present grade GS-5 through grade GS-15. The broader zones would reduce the number of border-line controversial cases which often create friction between line personnel and position classifiers.

d. Revise the Classification Act of 1949 by abolishing specific step rates and provision for periodic step increases for grades GS-13, GS-14, and GS-15. Substitute for those provisions salary increases on the basis of not more than one per year and make the amount of increase to be not less than, say, $250 a year or more than one-half the difference between the minimum rate of the grade and the maximum rate.

e. Provide for an independent and nonpartisan advisory body of scientists and engineers and public-spirited citizens to study the operation of the pay systems for scientists and engineers that are covered by these recommendations, to study the need for an integrated career corps of such scientists and engineers (a collaborative study with operating agencies), and to report to the President its findings in these and related matters. It is proposed that the study be limited to the scientist and engineer areas because of the present critical situations in these areas and because different problems exist in other areas.

4. Additional study by individuals or committees could produce useful information and recommendations on areas that are closely related to, or intertwined with rank-status pay plans for scientists and engineers, such as:

a. The possibility that entrance to a proposed Research and Development Corps should be planned as eventually beginning at a level lower than that recommended for immediate action.

b. The national effects, favorable and unfavorable, of changing the salary basis for scientists and engineers in research and development to fair competition with nongovernmental activities, either on a local or a national prevailing rate basis.

c. The extent, if any, to which the national interests make it desirable to provide a special pay raise under existing pay plans for scientists and engineers that would be different from the amount of any raise for other groups.

d. The practicability of decentralizing to agencies the authority currently residing in the Civil Service Commission to pay new recruits and present employees above the minimum step of the grades—making it on the basis of agency need and occupational specialty rather than on the broad occupational coverage that is now used.

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ENTOMOLOGY.—*A new subfamily, genus, and species of Lygaeidae (Hemiptera-Heteroptera) from Australia.* CARL J. DRAKE, Smithsonian Institution, and NORMAN T. DAVIS, University of Connecticut.

(Received December 15, 1958)

The present paper designates a new subfamily of bugs in the very large and heterogeneous family Lygaeidae to hold a remarkable species and genus described as new herein from Australia. The type series of 24 specimens of the new species were all collected by the Australian hemipterist Henry Hacker in Queensland.

Since the hierarchal characters of the undescribed species were found inapplicable for its inclusion in any of the present subfamilial taxa of Lygaeidae, it has been necessary to erect a new genus and new subfamily for its reception. These new categories are being named in honor of the lygaeid specialist Dr. James A. Slater, who is now engaged in classifying and cataloguing this family of insects for the world.

In their comprehensive check-list of the families and subfamilies of Heteroptera, China and Miller (1955) recognize 15 subfamilies in the family Lygaeidae. The fundamental subfamily classification of Lygaeidae was established by Stål (1862, 1865, 1872) and has remained essentially the same except for the addition of five subfamilies by Berg (1879), Reuter (1878) Douglas and Scott (1865), Breddin (1907), and Barber and Bruner (1933). Additional subfamily characters have been developed by Hutchison (1934), Slater and Hurlbutt (1957), Ashlock (1957), and Scudder (1957). Analytical keys to the subfamilies of Lygaeidae for various regions of the world may be found in the publications of Stål (1862, 1865, 1872, 1874), Walker (1872), Saunders (1892), Barber (1917), and Stichel (1925, 1957).

For many helpful suggestions and advice on phylogeny and classification, we wish to express our sincere thanks to the following hemipterists: Dr. W. E. China, British Museum (Natural History), London; Dr. J. Carayon, Muséum National d'Histoire Naturelle, Paris; Dr. J. A. Slater, University of Connecticut, Storrs, Conn.; and Dr. R. I. Sailer, H. G. Barber, and P. D. Ashlock, all of the U. S. Department of Agriculture, Washington, D.C. The illustrations were prepared as follows: Figure 1 was drawn by Arthur Smith, artist, British Museum (Natural History), London; the photograph of figure 2 is by Dr. J. Carayon, Muséum National d'Histoire Naturelle, Paris; the remainder were prepared by the junior author.

MORPHOLOGY

In order to determine accurately the characteristics and systematic position of this insect, the following detailed analysis of its morphology has been made:

Head: The general shape of the head may be characterized as being distinctly broad and short and moderately declivent (Figs. 1, 3). The compound eyes are strongly protruding and widely separated and have rather coarse facets. The eyes are almost contiguous with the thorax. The ocelli are present. The tylus is narrow and strongly produced anteriorly, while the juga are short, flat, and inconspicuous. The bucculae are well developed and open in front, extending back over about a third of the ventral surface of the head. The beak is 4-segmented and straight and reaches to just beyond the procoxae. The antenniferous tubercles are moderately small, and the antennae are short and 4-segmented. The small segments are rather thick and subcylindrical except for the last segment, which is fusiform (Fig. 4).

Thorax: The prothoracic coxal cavities are closed posteriorly (Fig. 6), and the pleural suture is distinguishable only on the prothorax. The meso- and metathoracic sterna are fused, but the intersegmental suture is distinct. There are well-developed scent gland ostioles (SgO) on the metathorax. Internally the metathoracic scent gland consists of a median, unpaired, reservoir (Fig. 10, SgR) into which lateral, branching scent glands open (Sg). The afferent ducts of the scent-gland reservoir pass through the base of the metasternal apophyses to their external

opening in the scent-gland ostioles. The structure of the scent gland is essentially the same as is found in other lygaeids as well as in most other families of Pentatomorpha except the aradids.

The metacoxal articulation is the trochalopodous type. The tarsi are 3-segmented (Figs. 7, 8, 9), the second segment being small and incompletely fused to the third; arolia are present.

Wings: The clavus and corium are distinct, and the membrane appears to have a reticular pattern of venation (Figs. 1, 2). However, there are five distinct longitudinal veins extending through the membrane, and the reticulation has probably developed secondarily. The second and third longitudinal veins are in some cases partly coalesced at the base (Fig. 1), and in others they are entirely separate.

The metathoracic wing venation is greatly reduced (Fig. 11). The terminology used here for the veins follows that of Leston (1953) and of Slater and Hurlbutt (1957). The subcosta is absent; the radius (R) is well developed; the hamus is not distinguishable except possibly as a broad, indistinct veinlike thickening between R and Cu near the base of the wing. The distal branch of the media from R, characteristic of the pentatomorphs, is in this insect only a small stub. The cubitus (Cu) is distinct and is followed by the bifurcate vanal furrow (VF). The intervanal veins are absent, and the vanal veins (V) are present and fused basally. The so-called jugum is absent.

Abdomen: The first abdominal segment is reduced in a manner characteristic of Heteroptera, and thus only the median tergite of that segment can be distinguished (Fig. 12, I). Segments II through VII are distinct, and all the pregenital terga are fused to one another except for tergites II and III, between which there remains an intersegmental membrane. On the venter of the abdomen the second, third, and fourth segments are fused, but the intersegmental sutures are distinct (Fig. 13). The remaining segments are free ventrally. The connexiva are distinctly formed, and the dorsal connexival sutures are modified into convoluted membranes (Fig. 12, CxM) which enable dorso-ventral expansion and contraction of the abdomen. The ventral connexival sutures are very indistinct (Fig. 13). The first abdominal spiracles are apparently absent: spiracles II through VI are dorsal on the connexivum (Fig. 12), and spiracle VII is ventral on the connexivum (Figs. 13, 19). Spiracle VIII of the female is also ventral and is normally concealed under the seventh segment (Fig. 14); the eighth spiracle of the male is absent. Two closely set pairs of trichobothria are found on the venter of segments III and IV; a widely separated pair is found on each side of the fifth and sixth segments near the connexival suture, and a single trichobothrial hair is found on each side of the seventh segment (Fig. 13). Scars of the nymphal scent glands are present between tergites IV and V, and V and VI (Fig. 12, Sg).

Female genitalia and genital segments: The eighth and ninth tergites are compressed ventrad and lie in an almost vertical plane, and the tenth segment is reduced to a small tubular sclerite projecting from beneath the ninth tergum (Fig. 14, X). The seventh segment is very deeply cleft

FIG. 1.—*Slaterellus hackeri*, n. gen. and sp.

mid-ventrally and normally overlaps the base of the ovipositor (Fig. 13, VII). When the ovipositor is in use, its anterior end is extended downward and posteriorly into the position shown in Fig. 14. This manner of extension of the ovipositor is especially characteristic of the lygaeids. In this extended position the gonocoxopodites (valvifers) of the eighth segment are seen to be large triangular sclerites (Fig. 14, Gcp 1). The gonocoxopodites of the ninth segment are not shown but are considerably reduced and lie beneath the ventral margins of that segment. The gonapophyses (valvulae) of the eighth segment extend from the anterior apex of the gonocoxopodites and are joined ventrally by a membrane (Fig. 14, Gap 1). The first gonapophyses are also attached to the ventral margins of the ninth paratergites by means of sclerotized rods, the inner rami, extending from their base (not shown). The second gonapophyses are joined for most of their length and are united to the first gonapophyses by the usual tongue-in-groove mechanism found in the heteropteron ovipositors. The third gonapophyses (= styloids of Dupuis, 1955) although usually present in other Hemiptera, can not be distinguished.

Internally the female genital chamber consists of a simple cuticular sac. Posteriorly its lumen extends into the ovipositor, and the common oviduct extends from it anteriorly. Arising from the roof of the genital chamber there is a complex tubular gland, the spermatheca (Fig. 15). At the base of the spermatheca the roof of the genital chamber is differentiated into a pouch-like structure with a groove extending posteriorly from it. This structure possibly functions to direct the vesica of the phallus (see below) into the spermatheca during copulation. The spermatheca consists of a double tube, the *ductus receptaculi* (DR), at the end of which is a distinctive chamber, the *capsula seminis* (Ca S). Various studies of other Heteroptera show that the spermatozoa are retained in the seminal capsule. The distal portion of the duct is sclerotized (PI) and is possibly equivalent to what has been termed the *pars intermedialis* in the pentatomid spermatheca (Dupuis, 1955). The proximal end of this structure is encircled by a ridge which presumably serves for the attachment of muscles extending from it to the lower rim of the seminal capsule. In the lumen of this duct there is a second and much narrower duct which also extends from the genital chamber to the seminal capsule.

FIG. 2.—*Slaterellus hackeri*, n. gen. and sp.

Male genitalia and genital segments: The eighth segment of the male is reduced considerably, and only the ventral portion of it is sclerotized (Fig. 19, VIII). This segment and the ninth, or *pygophore* (Pg), are normally retracted compactly into the seventh segment. The tenth and eleventh segments are very reduced and are incorporated into the *proctager*, which lies over the top of the pygophore (Fig. 16). The parameres (Fig. 17) are symmetrical and are similar in form to those found in many lygaeids. The phallus is extremely small, and it has been impossible to obtain it in the erect condition and to study many of the details of its structure. At its base is the usual stirrup-shaped *plaque basalis*, or stapes (Fig. 18, BP). The phallus is clearly differentiated into *phallosoma* (Ps) and *endosoma* (Es), and the latter is in all probabil-

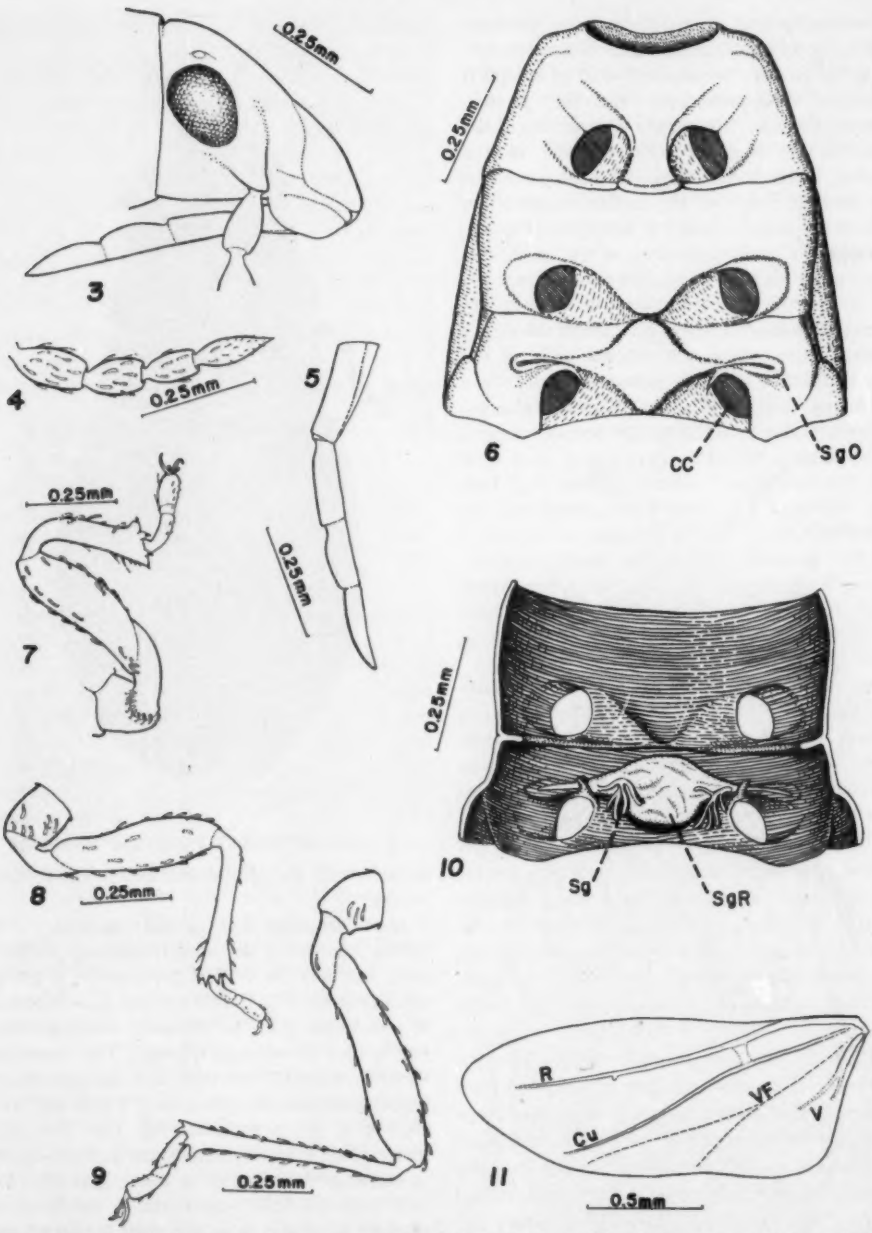
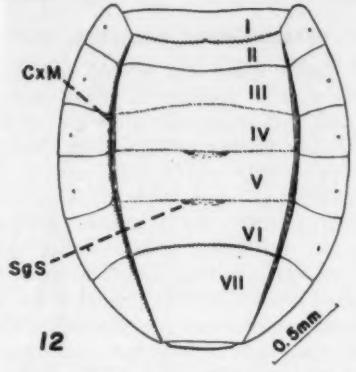
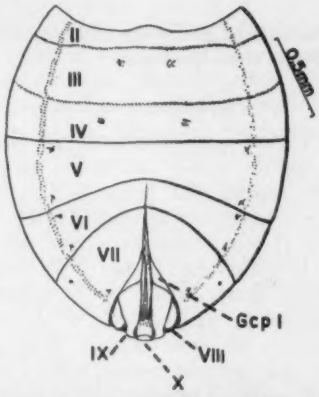
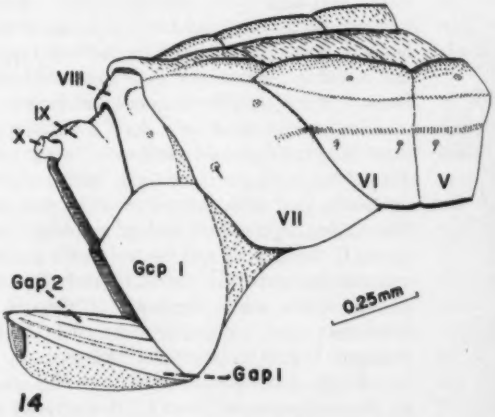
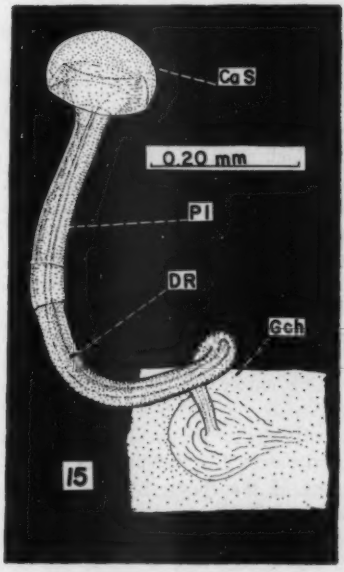


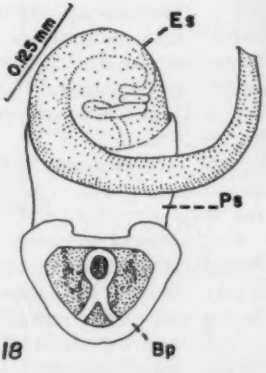
FIG. 3–11.—*Slaterellus hackeri*, n. gen. and sp.: 3, Lateral view of head; 4, antenna; 5, lateral view of labium and labrum; 6, ventral view of thorax with legs removed (CC, coxal cavity; SgO, scent-gland ostiole); 7, left prothoracic leg; 8, right mesothoracic leg; 9, right metathoracic leg; 10, internal view of meso- and metathorax showing scent-gland apparatus (Sg, scent gland; SgR, scent-gland reservoir); 11, metathoracic wing (Cu, cubitus; R, radius; V, vanal veins; VF, vanal fold).

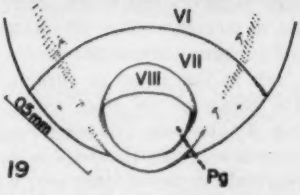












FIGS. 12–19.—*Slaterellus hackeri*, n. gen. and sp.: 12, Dorsal aspect of female abdomen (CxM, connexival membrane; SgS, scent-gland scars); 13, ventral aspect of female abdomen (Gcp 1, first gonocoxopodite); 14, lateral aspect of female abdomen with ovipositor extended (Gap 1, first gonapophysis; Gap 2, second gonapophysis; Gcp 1, first gonocoxopodite); 15, spermatheca (CaS, *capsula seminalis*; Gch, genital chamber; DR, *ductus receptaculi*; PI, *pars intermedialis*); 16, pygophore from above; 17, right paramere from lateral aspect; 18, phallus from dorsal aspect (Bp, basal plate; Ps, phallosoma; Es, endosome); 19, ventral view of terminal segments of male (Pg, pygophore).

ity differentiated into *vesica* and *conjuctiva*. The phallosoma lacks processes.

SYSTEMATIC POSITION

The ventral trichobothria, the type of spermatheca, and the type of phallus are the principle features relating this insect to the group of families of Geocorisae designated as the Pentatomorpha (Leston, Pendergrast, and Southwood, 1954). Of the several families of Pentatomorpha this insect clearly belongs to the Lygaeidae, as is indicated by its possession of the following combination of characteristics: Ocelli present; labium and antennae 4-segmented; tarsi 3-segmented; antennae inserted below a line from the middle of the eyes to the apex of the tylus; five longitudinal veins in the membrane of the hemelytra.

This insect differs from all other lygaeids in having the longitudinal veins of the membrane irregularly connected to one another by cross-veins which form a variable reticular pattern. It also differs from all other lygaeids except the Malcinae and Chauliopinae in having a vestiture of short, scalelike hairs. However, in addition to the characteristic venation of the membrane it is unlike these subfamilies in having closed coxal cavities and in having a different arrangement of abdominal spiracles. It appears to be most closely related to the Blissinae, since it has the same pattern of distribution of abdominal spiracles as the blissines as well as having a head with similar proportions of width to length, similarly shaped pronotum, and similar characteristics of the clavus and claval commissure. The unusually short corium of this insect is also characteristic of some but not all blissines. In addition to the very distinctive vestiture and membrane venation, this insect differs from the Blissinae in lacking swollen fore-femora and in having a punctate corium and clavus.

The lack in this insect of certain additional definitive characters of other subfamilies may be noted. Unlike most Megalonotinae, the suture between segments IV and V is straight and complete, and the paired setae near the eyes are lacking. Unlike the Lygaeinae and Cyminae the hind margin of the pronotum is not convex. The sulcate tylus characteristic of most Geocorisae is lacking and unlike the Megalonotinae, Oxycareninae, Heterogastrinae, and Pachygronthinae the fore-femora are not armed.

Slaterellinae, n. subfam.

Body clothed above and beneath and on appendages with a vestiture of short, scalelike hairs; head with transocular width greater than median length, inserted into pronotum almost to eyes; eyes strongly convex, ocelli present, bucculae moderately short, high, open in front. Forefemora unarmed, not incrassate; tarsi 3-segmented and with arolia; metacoxae trochalopodous; fore-coxal cavities closed. Metathoracic scent gland ostioles distinct; pronotum not constricted into anterior and posterior lobes. Mesothoracic wings with corium short and truncate, forming approximately the basal fourth of the wing, the membrane correspondingly longer; sides of the clavus almost parallel, claval commissure short but more than half as long as the scutellum; membrane with five longitudinal veins that are irregularly connected to one another by cross-veins so as to form a variable and indefinite network. Metathoracic wings with distal branch of media vestigal, hamus reduced or absent, and with intervanal veins and jugal lobe absent. Spiracles dorsal on connexival segments II through VI and ventral to the connexivum on segments VII and VIII, and with VIII absent in the male. Segments II through IV fused but with sutures distinct and straight. Segment V and VI narrowed and segment VII completely divided midventrally in the female. In the male segment VI and VII narrowed midventrally and segment VIII and IX of the female reduced and mostly concealed beneath tergite VII. Pygophore of male concealed beneath tergite VII and with symmetrical parameres. Spermatheca of female terminating in a bulb.

Type genus, *Slaterellus*, n. gen.

Slaterellus, n. gen.

Head depressed, sloping gently forward, transocular width slightly greater than anterior width but less than posterior width of pronotum, and with tylus conical and projecting, jugum short and flat, antenniferous tubercles small, ocelli widely separated, bucculae extending backward forming very low obliquely converging carinae, eyes exserted, large, and widely separated. Antennae thick, very short, scarcely longer than the head. Pronotum depressed, punctate, with lateral margins gradually converging anteriorly, hind margin roundly excavated. Legs with sec-

ond tarsal segment reduced and fused to third. Hemelytra not extending to the apex of the abdomen nor covering the connexival segments; clavus and corium sparcely punctate. Ventral trichobothria on segments III and IV consisting of two patches with a pair of closely set hairs, on segments V and VI a pair of patches on each side with a single hair, and a single patch with one hair on each side of segment VII.

Type species, *Slaterellus hackeri*, n. sp. This monobasic genus is known only from the Australian mainland.

Slaterellus hackeri, n. sp. (Figs. 1, 2)

Small, oblong, fuscous-brown tinged with grayish or testaceous, with blackish patches on head and pronotum, usually also with broad, blackish fuscous; hemelytral membrane grayish with veins fuscous. Antennae (Fig. 4) dark fuscous. Legs (Figs. 7, 8, 9) brownish fuscous with femora largely blackish fuscous. Modified hairy vestiture of body and appendages whitish. Length 2.90 mm (male), 3.34 mm (female); width 1.30 mm (male) and 1.50 mm (female).

Head wider across eyes (0.80 mm) than median longitudinal length (0.55 mm), interocular space slightly longer (0.60 mm) than median length of head (0.55 mm), apex extending slightly beyond tips of first antennal segments; eyes moderately large, strongly excerted, slightly less than half of their width extending laterally beyond front margin of the pronotum; ocelli widely separated, with space between them twice that between an eye and an ocellus. Antennae short, stout, moniliform, 0.54 mm long, subequal in length to width of vertex, segmental measurements: I, 13; II, 10; III, 9; IV, 13; (80 units equal 1 mm.). Labium moderately stout, 4-segmented, extending to base of prosternum. Bucculae very broad, very short, with cariniform bases converging sharply inward. Orifice of metathoracic stink gland plainly visible on metapleura and provided with an upright channel (Fig. 10). Legs short, stout, the anterior pair apparently subfossorial.

Pronotum trapezoidal (Fig. 1), slightly depressed, coarsely but not very closely punctate, broadly roundly excavated behind, wider across base (1.25 mm) than front margin (0.85 mm). Abdomen 1.25 mm long, widest a little behind middle; connexiva wide, very thick, moderately reflexed so as to form a fairly deep trough with abdominal tergites; hemelytra (Fig. 1) not extending to tip of abdomen or covering most of connexival segments; basal coriaceous part very short, extending less than half its length beyond apex of scutellum. Membrane overlapping apically so as to be jointly rounded behind, covering very little of connexival segments and of seventh abdominal tergite (Fig. 1). Scutellum moderately large, triangular, wider across base than median length (38:22), with median carinae and rimmed edges prominently raised. Venation of metathoracic wings as in Fig. 11. Male genitalia as in Figs. 17 and 18. Female genitalia as in Figs. 14 and 15.

Holotype (male) and *allotype* (female), Goodna, Queensland, Australia, December 12, 1926, Drake Collection (U.S. Nat. Mus.). *Paratypes:* 20 specimens same data as holotype; 2 specimens, Manjo District, Queensland, November 1927, and 2 specimens, Forest Hills, Queensland, January 1933; all collected by Hacker.

Paratypes have been deposited in the British Museum (Natural History) London; California Academy of Science, San Francisco; Muséum National d'Historie Natural, Paris; U.S. National Museum, Washington, D.C., and the collections of Drs. J. A. Slater and N. T. Davis, Storrs, Conn., and T. W. Woodward, Brisbane, Australia.

This singular species is named in honor of the eminent entomologist Henry Hacker, whose large collection of insects contains many rare and undescribed species of Australian Hemiptera.

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It is the great destiny of human science, not to ease man's labors or prolong his life, noble as those ends may be, nor to serve the ends of power, but to enable man to walk upright, without fear, in a world which he at length will understand and which is his home. Charles Darwin did not kill the faith of mankind. He wrought mightily, and others with him, for a newer and greater faith—faith in universal order, whose secrets open themselves to men truly free to question, to communicate, and to arrive at agreement as to what they have seen.—PAUL B. SEARS.

ICHTHYOLOGY.—*Description of a new sandfish,* Kraemeria sexradiata, *from Japan, with special reference to its osteology.*[1] KIYOMATSU MATSUBARA and TAMOTSU IWAI, Kyoto University, Maizuru, Japan. (Communicated by Leonard P. Schultz.)

(Received November 6, 1958)

The sandfishes referred to the genus *Kraemeria* are inhabitants in the sandy shallow waters of the tropical Pacific and are by no means familiar even to ichthyologists. Remarkably enough, the members of this inconspicuous little group, attaining about 40 mm in total length, appear to exhibit a high endemism, and no one has found them before in the Japanese area.

Although the genus *Kraemeria* has been included in the family Trichonotidae or Gobiidae or sometimes placed in the independent family Kraemeriidae, their systematic position was in a state of confusion until Gosline's (1955) paper placed the family Kraemeriidae in the suborder Gobioidei based upon the results of his osteological studies.

The recent expedition to the Amami Islands, Kagoshima Prefecture, greatly augmented our limited knowledge of the ichthyological fauna of the southernmost district of Japan. Among a number of fishes collected, there were three specimens of the genus *Kraemeria* possessing sufficient distinctive characters to warrant the erection of a new species. The descriptions presented below are based on the material obtained from the sandy tide pools at Ankyaba and Usyuku, Amami Oshima, the largest island of Amami Islands.

In order to make a comparison of osteological features of the species with those of a known species, *K. samoensis,* a study of the bones of the present new species was undertaken. Counts and measurements of the bodily parts were made according to standard practice as outlined by Matsubara (1955, pp. 60–69). In the osteological examination the skeletal elements were stained with alizarin red and cleared with potassium hydroxide and glycerol.

Kraemeria sexradiata, n. sp. (Fig. 1)

SUNA-HAZE (new Japanese name)

HOLOTYPE.—MIKU (Marine Biological Institute of Kyoto University) no. 1744, a mature male specimen, 33.0 mm in standard length (38.0 mm in total length), collected in the tide pool of Usyuku, Amami Oshima, on July 10, 1958.

PARATYPES.—2 specimens, MIKU no. 1745, 30.2 and 30.5 mm (36.5 and 36.0 mm), collected in the tide pool of Ankyaba, on June 30, 1958.

Diagnosis.—K. sexradiata is a dwarf species, full-grown ova are found in a small female measuring 36.0 mm in total length. The body is slender and compressed laterally. The eye is very small. The lower jaw strongly projects far beyond the upper jaw. The pectoral fin consists of 6 rays, the lower 5 are branched. Scalloped flaps on the lower edge of the gill-cover number 3 to 5. In the fresh condition prior to preservation, the body is transparent. Counts and proportional measurements of bodily parts of types are shown in Table 1.

TABLE 1.—COUNTS AND PROPORTIONAL MEASUREMENTS IN TYPES OF KRAEMERIA SEXRADIATA

Items	Holotype	Paratypes	
Standard length in mm	33.0	30.5	30.2
Dorsal fin	V, 14	V, 14	V, 14
Anal fin	I, 13	I, 13	I, 13
Pectoral fin	6	6	6
Ventral fin	I, 5	I, 5	I, 5
Gill-rakers	9	—	9
Vertebrae	—	—	26
Sex	male	female	male
In standard length:			
Head length	4.1	3.8	3.8
Depth of body	8.5	8.2	8.6
Predorsal distance	3.1	3.2	3.1
Preanal distance	1.8	1.8	1.8
Length of pectoral fin	12.2	11.7	12.1
Depth of caudal peduncle	16.5	15.3	15.1
Length of caudal peduncle	16.5	16.9	16.8
In head length:			
Snout	6.7	6.7	6.7
Diameter of eye	26.7	26.7	26.7
Interorbital width	20.0	20.0	20.0
Length of upper jaw	3.8	4.0	4.2
Length of lower jaw	2.7	2.7	2.7

[1] Contributions no. 1 from the Marine Biological Institute of Kyoto University. The Institute is located at Tannawa, Sennan-gun, Osaka Prefecture. It was established for our Department by the Nankai Electric Railway Co., Ltd., on March 20, 1958. We wish to acknowledge generous financial assistance from the Company.

Description of the holotype.—Body slender and compressed laterally, without scales. Head rather broad, about twice as wide as body. Opercle relatively large and the lower edge armed with 5 scalloped flaps. Posterior margin of membranous gill-cover extending over base of pectoral. A series of minute sensory papillae present along lower edge of preopercle, upper lip fold, and mandibular fold. Small nasal tube midway between tip of snout and eye. Eye very small. Mouth moderately large and obliquely directed. Lower jaw projecting far beyond tip of upper jaw when mouth is closed. Gill-membranes extend forward and narrowly joined to isthmus before a vertical through posterior margin of preopercle. Nine gill-rakers on ceratobranchial bone of first gill-arch, but no rakers on epibranchial and hypobranchial. No gill-rakers on other gill-arches. Pseudobranchae absent. Branchiostegal rays slender and 5 in number. Small conical teeth closely set on both upper and lower jaws, slightly curved, directed inward.

Dorsal fin consisting of 5 anterior spines and 14 soft rays, the posteriormost one bilobed. First dorsal spine originating above a vertical through posterior end of pectoral. Anal fin with 1 spine and 13 soft rays, the last one bilobed. Anal spine arises below membrane between second and third soft dorsal rays. Pectoral fin rays 6, all branched except the uppermost simple one. Pelvic fin with 1 spine and 5 branched soft rays, inserted below a vertical through posterior margin of opercle. Caudal fin 6 + 7 + 6 + 6.

Anal papilla slender, the posterior tip pointed.

In fresh condition prior to preservation body and fins transparent.

Description of paratypes.—The systematic characters of paratypes generally agree with those of the holotype except for scalloped flaps on the lower edge of the opercle, the flaps being 3 in one specimen and 4 in the other.

Remarks.—In some characters this new species closely resembles *K. cunicularia* Rofen but differs in having 6 pectoral rays (8 or 9 in *cunicularia*) and slender anal papilla with pointed posterior tip (flat anal papilla with notched posterior tip). Compared with the other species, *K. nudnum*, *K. sexradiata* is seen to differ in the fewer number of pectoral fin rays, 6 as against 8 (Regan, 1908, p. 246), and in having the scalloped flaps on the opercle (3–5 versus none).

Although Rofen (1955, p. 182) utilized the number of scalloped flaps on the lower edge of the opercle as an important character in distinguishing the species of this group, our specimens show a rather extensive variation in this character as aforementioned.

Name.—*K. sexradiata* is named in reference to the six pectoral rays of this fish. The Japanese name Suna-haze means sand-goby, in reference to its habitat.

OSTEOLOGY

In this section the skeletal system of *K. sexradiata* is described based upon the dissection of a specimen, 30.2 mm in standard length.

Jaws (Fig. 2, A).—The upper jaw consists of a premaxillary and maxillary. There is no supramaxillary. The premaxillary is a stout bar forming the anterior half of the upper edge of the gape, and armed with about 20 small conical teeth directed slightly inward. The maxillary is a well ossified curved bone overlying the dorsal surface of the premaxillary. The posterior end reaches to the lower prong of the dentary.

The lower jaw consists of a dentary, articular and angular. The dentary is the largest bone, bearing about 23 small conical teeth on the upper surface. At the anterior end the bone strongly projects downward. Posteriorly the dentary is bifurcated, the lower prong is longer than the upper one. The articular is a slender forked bone attaching to the posterior border of the dentary

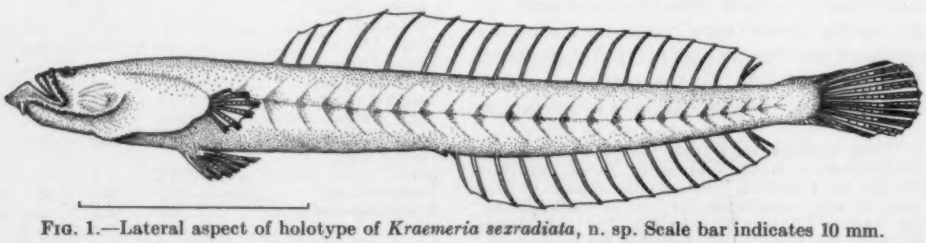

FIG. 1.—Lateral aspect of holotype of *Kraemeria sexradiata*, n. sp. Scale bar indicates 10 mm.

and abuts on the condyle of quadrate posteriorly. The lower wing of the bone becomes slenderer anteriorly and reaches to below the middle of dentary. The angular is a small heavy bone lying on the posterior end of the articular.

Suspensorium (Fig. 2, A).—The hyomandibular is roughly triangular in shape. Its dorsal border articulates along the ventrolateral margin of the pterotic. Posteriorly it articulates with the opercle by a small condyle. Anterior to the hyomandibular there extends a slender metapterygoid. The quadrate is a relatively large bone, bearing 3 projections. The first projection on the dorsal surface abuts against the pterygoid. The second one on the dorsoposterior edge meets the anterior end of the metapterygoid, and the last one on the posterior edge extends posteriorly along the dorsal border of the preopercle. The bone bears a heavily ossified condyle at its ventral corner for the articulation of the articular of the mandible. It is a remarkable fact that there is a broad interosseous space between the

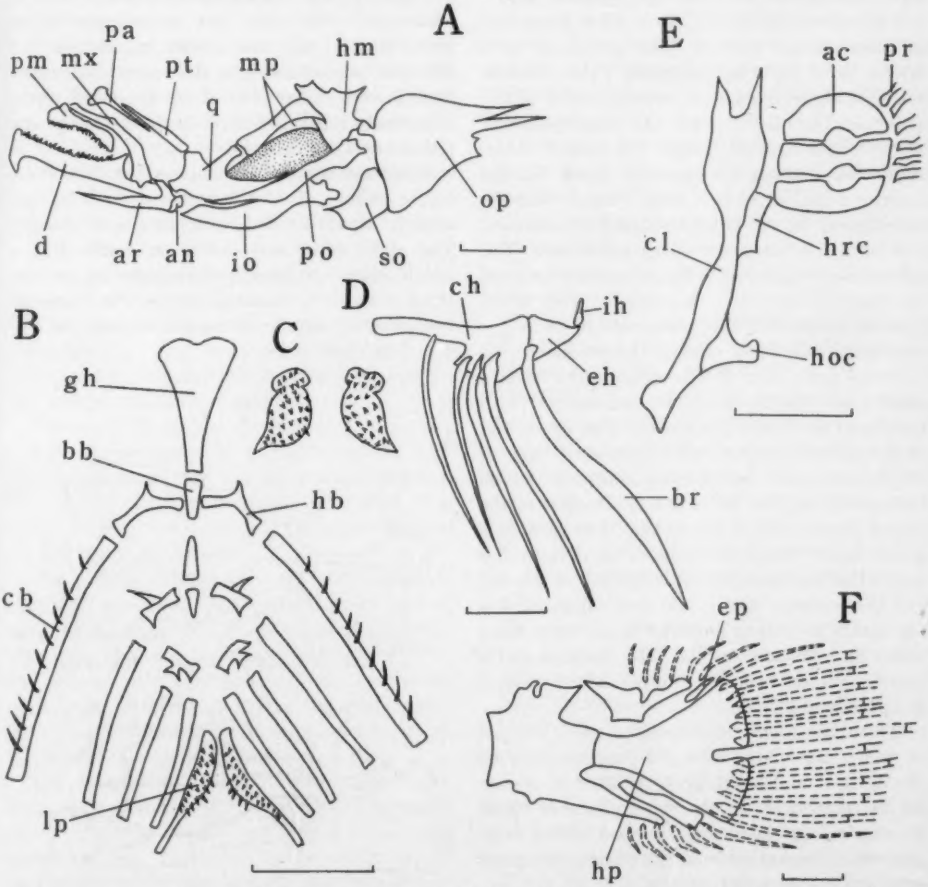

FIG. 2.—Lateral aspects of jaws, suspensorium (A), lower half of branchial arches (B), upper pharyngeal teeth (C), hyoid arch (D), shoulder girdle (E), and caudal skeletons (F) of *K. sexradiata*. (Each sale bar indicates 1 mm. *ac*, actinost; *an*, angular; *ar*, articular; *bb*, basibranchial; *br*, branchiostegal ray; *cb*, ceratobranchial; *ch*, ceratohyal; *cl*, clavicle; *d*, dentary; *eh*, epihyal; *ep*, epural; *gh*, glossohyal; *hb*, hypobranchial; *hm*, hyomandibular; *hoc*, hypocoracoid; *hp*, hypural plate; *hrc*, hypercoracoid; *ih*, interhyal; *io*, interopercle; *lp*, lower pharyngeal; *mp*, metapterygoid; *mx*, maxillary; *op*, opercle; *pa*, palatine; *pm*, premaxillary; *po*, preopercle; *pr*, pectoral fin ray; *pt*, pterygoid; *q*, quadrate; *so*, subopercle.)

hyomandibular - metapterygoid - quadrate strut and the preopercle (dotted area in Fig. 2, A).

Symplectic and mesopterygoid could not be detected, although it is difficult to manifest the absence of these bones.

The pterygoid is a thin, slender, rodlike bone lying between the quadrate and the palatine. Anteriorly it overlies the posterior portion of the palatine. The palatine is a small and edentulous T-shaped bone. Its dorsoanterior condyle articulates with the ethmoid region of the cranium with an intervention of the cartilagenous band.

Opercular series (Fig. 2, A).—All four opercular elements are present. The preopercle is a slender bone tapering anteriorly. The anterior half of it abuts against the ventral border of the quadrate. Dorsally it meets the ventroposterior border of the hyomandibular. The opercle is the largest bone among the opercular series. On the anterior edge, it bears a small condyle for the articulation of the hyomandibular. Posteriorly it is bifurcated into two sharp projections. The subopercle is quadrant in shape, and lies between the opercle and the interopercle. The interopercle, resembling the preopercle in shape, is attached to the lower edge of the preopercle.

Hyoid arch (Fig. 2, D).—The interhyal is a small bone, rodlike in shape, and capped with cartilagenous band at each end. The upper end of the bone is inserted on the proximal side of the juncture between the hyomandibular and the preopercle, and the lower end is attached to the dorsoposterior end of the epihyal. The epihyal is a flat, nearly triangular bone. The ceratohyal is a well ossified bone. The anterior half is slender, but the posterior half is abruptly expanded, being nearly as wide as long and about three times wider than the anterior half. The posterior end is sturdily joined with the epihyal. The hypohyal is not discernible.

There are 5 long branchiostegal rays, the last of which articulates with the junction between the epihyal and ceratohyal. Another 4 are set on the ceratohyal, the anteriormost one of which is attached to the slender portion of the bone and widely separated from the other 3 which are attached to the wider section.

The glossohyal is edentulous. It is a flat, fan-shaped bone having a shallow notch at the tip (Fig. 2, B, *gh*). Posteriorly it articulates with the first basibranchial.

Branchial arch (Fig. 2, B).—The branchial apparatus consists of five branchial arches diminishing in size posteriorly. The median floor of the arches is composed of 3 basibranchials which lie longitudinally behind the glossohyal. All bones are rodlike in shape. There are hypobranchials on the first three branchial arches. The hypobranchial of the first arch is a slender bone with a projection at the anterior bend, and meets the first basibranchial. That of the second arch is similar to the first bone in shape, but about half as long as the first one. The third one is modified into a small tridentate bone. There are five slender ceratobranchials decreasing in length posteriorly. Only the first ceratobranchial is armed with a single row of short gill-rakers. The fifth one is modified into the lower pharyngeal bone bearing three rows of small conical teeth, apparently separated from the fellow of the opposite side (Fig. 2, B, *lp*).

Epibranchials are present on the first three arches. Since all of these bones are not well ossified, their detailed structures are obscure. The upper pharyngeal teeth are confined to a small patch on bony plate extending on the third and fourth branchial arches. The plates on two sides are not fused together along the median line (Fig. 2, C).

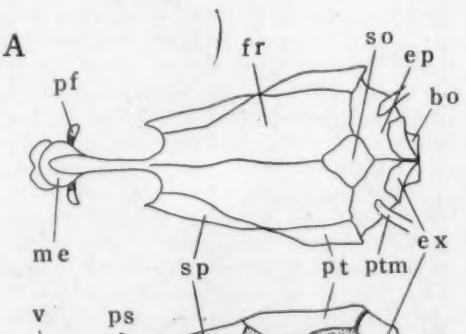

FIG. 3.—Cranium of *K. sexradiata*: (A) Dorsal aspect and (B) ventral aspect. (Scale bar indicates 1 mm. *as*, alisphenoid; *bo*, basioccipital; *ep*, epiotic; *ex*, exoccipital; *fr*, frontal; *me*, mesethmoid; *pf*, prefrontal; *po*, prootic; *ps*, parasphenoid; *pt*, pterotic; *ptm*, posttemporal; *so*, supraoccipital; *sp*, sphenotic; *v*, vomer.

Cranium.—On the dorsal aspect (Fig. 3, A), the anterior corner of the cranium is occupied with an unpaired thin bone which is thought to be mesethmoid. Anteriorly it is broadened and extends ventroanteriorly to the dorsal surface of the vomer.

The prefrontals are merely small rodlike bones on the lateral edges of the mesethmoid and not joined directly with the mesethmoid, but attached with the latter by an intervention to the cartilagenous patch.

The frontals are the largest flat bones covering a vast part of the top of the cranium. At the interorbital region, they are abruptly constricted in width and so securely fused together along the midline that the suture is not apparent on this region (Fig. 3, A, *fr*). The anterior end of the fused frontal overlies the mesethmoid. Behind the orbit each frontal expands and abuts against the sphenotic and pterotic laterally, and against the supraoccipital and epiotic posteriorly.

The dorsal surface of the sphenotic is narrowly exposed along the lateral border of the frontal.

The pterotics are slender bones lying behind the sphenotics. Each bone meets the frontal laterally and epiotic posteriorly. The latero-posterior end of the bone is pointed.

The parietals appear to be absent.

The supraoccipital is a median dorsal bone extending between the frontals and also epiotics. Its rhombic dorsal portion is well ossified. It is separated from the exoccipital by an intervention of the epiotic.

The epiotics form a portion of posterolateral edge of the cranium. The dorsoposterior part of each bone receives the anterior end of the posttemporal. The bone is bounded with the pterotic and frontal anteriorly and with the exoccipital posteriorly. Mesially it meets the counterpart of the opposite side at the midline, and separates the supraoccipital from the exoccipital.

The exoccipitals contribute to form most of the posterior surface of the cranium. They meet along the dorsal median line. Dorsally the bone slightly overlies the epiotic. In the ventral aspect they curve ventroanteriorly to meet the dorsoposterior edge of the basioccipital.

On the ventral aspect (Fig. 3, B), the vomer forms the anterior corner of the cranium. It is a fanlike bone with a rather deep notch at the tip. Posteriorly it becomes abruptly narrower, sliding under surface of the anterior part of the parasphenoid. No teeth could be found on the vomer.

The parasphenoid, running along the midline of the ventral surface of the cranium, is a long narrow bone. From near the bilobed posterior end over the basioccipital the bone widens anteriorly and sends the lateral wings on both sides extending toward the prootics. Then it becomes narrow between the orbits and the anterior end is inserted between the vomer and the ethmoid cartilage.

The median basioccipital forms the posterior end of the ventral surface of the brain case. Anteriorly, it is deeply excavated and each arm attaches to the parasphenoid and prootic. Posteriorly it is thickened to form a condyle for the articulation of the atlas.

There is no opisthotic. The portion of the otic bulla is covered by the interosseous membrane (posterior dotted area in Fig. 3, B).

Each prootic forms a suture for the alisphenoid anteriorly, for the parasphenoid ventrally, for the pterotic dorsally, and for the basioccipital posteriorly.

The alisphenoids are slender elements and they are united dorsoanteriorly under the frontals.

There is no basisphenoid.

Shoulder girdle (Fig. 2, E).—Although almost all the skeletal elements are present in the shoulder girdle, the ossification is imperfect. The posttemporal, hypercoracoid, and hypocoracoid are much reduced in size. The posttemporal is a simple strut and is bound tightly to the upper edge of the epiotic. Ventrally it articulates with the dorsal edge of the supraclavicle which is slender in shape.

The dorsal extremity of the clavicle is shallowly furcated. It extends ventroanteriorly and is forklike in general appearance.

The hypercoracoid, rectangular in shape, lies behind the clavicle. The dorsoposterior edge meets the lowermost actinost.

The hypocoracoid is roughly triangular in shape and attached to the posterior edge of the lower bend of the clavicle. It is well separated from both the hypercoracoid and actinosts.

There are 3 large actinosts with a large foramen between each of them, all of them lying a short distance behind upper portion of the clavicle (Fig. 2, E, *ac*).

No postclavicle could be recognized.

Caudal skeletons (Fig. 2, F).—All hypural bones are fused together and modified into a

fan-like plate (Fig. 2, F, *hp*). It is deeply excavated at the middle of the posterior border. The suture between the urostyle and hypural plate is obscure. There is a single epural above the upper border of the hypural fan. The neural process of the urostyle is separated from the hypural plate and directed upward. There is a splint-like bone between the hypural plate and the last haemal spine. The last two vertebrae contribute to support the caudal fin rays.

There are 26 vertebrae including hypural plate.

CONSIDERATIONS AND CONCLUSION

In general, the osteological features of *K. sexradiata* agree with those of *K. samoensis* as given by Gosline (1955, pp. 158–170), with the exception of some minor points. The differences between them are as follows: (1) Gosline drew a large symplectic bone below the metapterygoid, but so far as our observations go, the bone recognized by him as symplectic appears to be a bony shelf extending from the metapterygoid. Evidence that the interhyal bone articulates with the juncture between the preopercle and the posterior end of the quadrate strongly suggests that the reduced symplectic bone, if present, may lie near this area. (2) Although Gosline stated that the alisphenoid appears to be lacking, in our specimen this paired bone is recognizable in front of the prootic. (3) Lower pharyngeals are evidently separated in our species versus they are entirely fused without suture in *samoensis*. That the individual bones of the skeletal system in such small fishes as *Kraemeria* are not sufficiently demarcated owing to unsatisfactory ossification might explain these differences.

Koumans (1931, p. 14) included the Psammichthyidae (=Kraemeriidae) in the order Gobioidea. Schultz (1941, p. 269) stated that *Kraemeria* has features that resemble the trichonotids more than the gobiids.

Gosline (1955, p. 165) placed *Kraemeria* in a distinct family Kraemeriidae and assigned the latter to the suborder Gobioidei on the basis of the following features: (1) the parietals are absent, (2) the branchiostegal rays are 5 in number, the first one of which is far separated from the others, (3) there is a broad interosseous space between the metapterygoid and preopercle, and (4) the hypural plate bears detached splint-like bone on both dorsal and ventral sides. He concluded that these features of *Kraemeria* agree with those of gobioid fishes but disagree with those of both blennid and trichonotid fishes.

Results of our osteological observation, as well as such peculiar external features as steeply projected lower jaw and scaleless body would be sufficient to justify the retention of *Kraemeria* in a separate family. On the other hand, the fishes of the genus *Kraemeria* seem to be closely related, in general physiognomy, to those of the family Trichonotidae. But, at the present, there is no adequate information on the osteological features of the trichonotid fishes, which will enable us to compare both groups. Accordingly, the decision whether the family Kraemeriidae belongs to the suborder Gobioidei or other separate suborder, should be withheld until such a time as more information becomes available concerning the anatomical features of the trichonotid fishes, although the fact that the pelvic fins are united for one-fifth the length of inner rays by a membrane in *Kraemeria tongaensis* and for their full length in *Gobitrichinotus radiocularis* (Rofen, 1958, p. 182), both of which are referred to Kraemeriidae, may support Gosline's conception concerning the allocation of Kraemeriidae to the gobioid group.

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"NIGHT-GOWNED" FISHES

There are fish that wear "nightgowns." They are among the most resplendent of all sea creatures. They have teeth in their throats. These are the "parrotfishes," a family distributed worldwide through tropical waters where they frequent coral reefs. The first systematic zoological description of this group as a whole, by Dr. Leonard P. Schultz, U. S. National Museum curator of fishes, has recently been published by the Smithsonian Institution.

The strange practice of donning night robes before retiring, cited in the report, is an observation by Dr. Howard E. Winn, of the University of Maryalnd, and presumably is restricted to one or two species found in West Indian waters. These fishes pass the hours of darkness resting on the shallow sea bottom. They lean against rocks, arms of coral, or other stable objects. Sometimes they retire inside conch shells. But as night approaches the fish starts secreting a transparent mucous envelope from a special secretory system. It starts with the mouth and is extended backward, until the transparent envelope completely encloses the body. There is a little flap with a hole in the center in front of the open mouth. There is another small hole at the rear. The mouth flap moves back and forth as the animal breathes. The openings assure a constant flow of water around the gills, without which the animal could not live.

The entire process of nightgown-making requires from a half hour to an hour-and-a-half. It stops entirely, Dr. Winn observed, whenever light was turned on the aquarium but was resumed immediately with darkness. As the folds progress the breathing rate is reduced. The purpose of wearing nightgowns can only be surmised. The thin garments, he believes, may afford some sort of protection against nocturnal enemies. Also it may protect the body from becoming surrounded by silt.

The gown-weaving, as well as the practice of spending the night leaning against some solid object, apparently is dictated by some nervous mechanism which is set off by darkness. So far as known, the practice is unique in nature. But, as cited by Dr. Schultz, this is only one of the parrotfish curiosities. Colors, of males, become more and more brilliant as adulthood is approached, and a fully matured individual of some species is one of the handsomest denizens of the deep. Females of some species, however, may remain throughout life rather drab individuals.

"Many species," says Dr. Schultz, "pass through from one to three color phases. In general these are juvenile, in which the color may consist of two or three alternating dark and light streaks, or spots that are dark or mottled pale and dark; immature, in which the color pattern is usually some shade of red, brown, or purple; and adult, in which the color pattern seems to be reached somewhat before or at sexual maturity, with the predominating colors generally green, blue, pink, red, orange, and yellow. A few species are brownish. Some of these are females, but the males predominate in shades of green or blue and with green teeth."

Color changes, it is explained, are a factor which makes species classification quite difficult. Living in the shelter of coral banks and quite secretive in their ways of life these parrotfishes, or Scaridae, have remained among the least known of the fish groups.

Their food, for the most part, consists of algae which are scraped from the coral branches. This necessitates the so-called pharyngeal mill, or teeth in the throat, designed to crush coralline algae, coral fragments, and other food items. The upper pharyngeal teeth are paired and fit snugly against the base of the skull. The number of rows on each upper pharyngeal bone varies from one to three, according to genera. The lower pharyngeals consist of a single bone with a toothed surface. This arrangement constitutes a grinding mill operated by powerful muscle attached to the shoulder girdle and base of the skull.

Some species, Dr. Schultz points out, apparently have a very wide distribution, while others have very restricted habitats, but more collecting in numerous island groups will be required before the distribution of individual species can be determined.

Major regions where these strange animals are found are the central and west Pacific, Hawaiian and Johnston Islands, some offshore islands of the east Pacific adjacent to the American continents, west Atlantic and Bermuda, east Atlantic, the Indian Ocean, Andaman Islands, and Ceylon. There are about 80 valid species for the whole world, the report says.

COMPRESSIVE PROPERTIES OF HUMAN ENAMEL AND DENTIN

For many years the National Bureau of Standards dental research laboratory has investigated the basic properties of dental materials in cooperation with the American Dental Association and the Federal dental services. As part of this program, a study was recently undertaken by J. W. Stanford and G. C. Paffenbarger, research associates of the American Dental Association, and J. W. Kumpula and W. T. Sweeney of the Bureau staff to obtain precise data on the compressive properties of human enamel and dentin.[1] Data derived from the work will be used in evaluating dental filling materials, in designing cavity preparations, and in demonstrating physical changes in teeth.

In the past, abundant information has been compiled on the properties of restorative materials used in dentistry, but relatively few data have been published about hard tooth tissue, the foundation for these materials. An obvious explanation for this lack is the limited supply of human enamel and dentin available, and the difficulties inherent in testing small specimens. However, since a successful dental restoration depends equally on the restorative material and the tooth, knowledge of both is necessary.

In the Bureau tests of human enamel, the highest strength, modulus of elasticity, and proportional limit were obtained for specimens of cusp enamel, the tapering projections on the crown of the tooth. Intermediate values for these properties were found for specimens prepared from the sides of teeth; and lowest values for the occlusal surface or chewing part of molar teeth. Although dentin showed a higher compressive strength than did enamel, it had a lower modulus of elasticity.

The specimens used in the tests were prepared from freshly extracted teeth. Made in the shape of cylinders 0.044 inch in diameter and from 0.075 to 0.082 inch in length, they were ground from block sections of enamel, dentin and combinations of the two. All cutting and grinding operations were accomplished under a steady dripping of water on the field of cutting.

After the specimen ends were made plane and parallel, the specimen was placed upright in a testing machine between two hardened steel platens. Because of the small size of the specimens, two optical strain gages had to be fastened across the specimen length on the sides of the platens (rather than on the specimen). These strain gages were used to determine the deformation occurring in the specimens under load. In conducting the tests, the 0–1,000-pound range of a 2,000-pound-capacity testing machine was uesd to measure the loads as they were applied.

The strain measurements included errors resulting from deformations in those portions of the steel platens within the gage length, and possible non-parallelism of the platens. To evaluate these errors, tests were conducted on metals for which the moduli of elasticity are well known. Small cylinders of carbon steel, aluminum alloy, and magnesium alloy, were prepared in a manner similar to that used in preparing the tooth specimens, and were tested in compression. The results obtained with these metals were used to correct the experimentally determined moduli of elasticity of the hard tooth tissues.

Stress-strain diagrams derived from the data showed an important difference between the enamel and the dentin. The enamel, largely inorganic, showed little plastic flow in comparison with the more organic dentin. This is also shown by the data in Table 1. It was found that the more brittle enamel broke at a load slightly higher than its proportional limit, while the dentin exhibited plastic flow from its proportional limit of approximately 25,000 psi up to its compressive strength of about 50,000 psi.

Average values computed for the three enamel areas range from 1.8×10^6 to 8.2×10^6 psi for modulus of elasticity; 15,000 to 34,000 psi for

TABLE 1.—COMPRESSIVE PROPERTIES OF HUMAN ENAMEL AND DENTIN

Material	Modulus of elasticity	Proportional limit	Compressive strength
	10^6 psi	psi	psi
Enamel:			
Cusp	8.2	34,200	40,200
Side	6.0	21,200	28,200
Occlusal surface	1.8	15,400	18,200
Dentin	2.2	25,100	50,400
Dentin and enamel	3.6	23,900	34,200

[1] For further technical details, see *Determination of some compressive properties of human enamel and dentin*, by JOHN W. STANFORD, G. C. PAFFENBARGER, JOHN W. KUMPULA, and W. T. SWEENEY, Journ. Amer. Dental Assoc. **57**: 487. 1958.

proportional limit; and 18,000 to 40,000 psi for compressive strength. In tests of dentin specimens, values determined for these three properties, in the same order, are 2.2×10^6 psi; 25,000 psi; and 50,400 psi. These values for dentin are comparable to values previously found by Peyton, Mahler, and Hershenov.[2] The crushing strength of both enamel and dentin earlier reported by G. V. Black[3] is not inconsistent with the values for compressive strength derived from the present study.

[2] *Physical properties of dentin*, by F. A. PEYTON, D. B. MAHLER, and B. HERSHENOV, Journ. Dent. Res. **31**: 366. 1952.

[3] *Physical characters of the human teeth*, by G. V. BLACK, Dental Cosmos **37**: 353. 1895.

EXPERIMENTAL MAP PAPERS CONTAINING SYNTHETIC FIBERS

The National Bureau of Standards, in work sponsored by the Army Engineer Research and Development Laboratories, has investigated the strength characteristics of synthetic-fiber map paper. Tests for dimensional stability, folding endurance, and bursting and tearing strengths were made on specimens of three experimental handsheets and two commercially produced papers. Results show that a polyester-cellulose sheet has high dimensional stability, a prerequisite for military map paper, and better strength properties than commercial map paper. A paper containing polyamide fibers has low dimensional stability, but exceptional folding, tearing, and bursting strengths.[1]

For many years the Bureau has conducted research on the properties of paper and related materials. In previous experiments a dimensionally stable paper, that is, a paper with low moisture expansivity, was developed by laminating two thin sheets to a backing of polyester film.[2] G. L. McLeod of the Bureau staff undertook the present study to find out whether synthetic fibers with less affinity for water than cellulose could impart the desired moisture stability to map paper. Also, while cellulose is and probably will remain the backbone of the paper industry, growing interest is being displayed in the use of synthetic fibers to improve the properties of special-purpose papers.

Initial attempts to prepare handsheets from a suspension containing 100 percent synthetic fibers were unsuccessful. The sheets tore and disintegrated when removed from the mold. A suspension was then prepared containing cellulose fibers and synthetic fibers in a 1-to-3 proportion. From this suspension it was possible to produce handsheets that could be manipulated and treated with an acrylic binding agent. After treatment, the sheets were dried for 1 hour in a forced-air oven, and cured in a flat-bed press at 160°C with a pressure of 300 lb/in.[2] for 45 seconds. The synthetic fibers in the three different handsheets were poylester, polyacrylate, and polyamide (nylon). Table 1 shows the results of tests on these handsheets compared with results obtained from all-cellulose sheets made with the same handsheet apparatus.[3]

Similar tests were conducted on machine-made paper containing 40 percent synthetic fiber, 40 percent cellulose rag fiber, and 20 percent acrylic binder. Only two of the synthetic fibers, polyester and polyamide, were used in the machine-made paper. Table 2 gives the results of these tests compared with identical tests on commercial map paper. Included in this table are the Federal specifications for map paper.

In general, test results of the handsheets and the machine-made paper follow the same pattern. The polyester-cellulose sheets are superior in dimensional stability to moisture, and have higher bursting, folding, and tearing strengths than does regular map paper. The polyacrylic-cellulose sheets, tested only in the form of experimental handsheets, are superior to the polyamide-cellulose and the all-cellulose sheets in dimensional stability but inferior to the polyester-cellulose sheets. The polyamide-cellulose paper has the lowest dimensional stability of all the papers tested, which makes it unsuitable for map paper. However, because of its exceptional folding endurance and high tearing strength, this paper map prove to be valuable for other purposes.

No difficulties were encountered in printing on

[1] For further technical details, see *Properties of some experimental map papers containing synthetic fibers*, by G. L. MCLEOD, TAPPI **41**: 430. 1958.

[2] *Improved dimensional stability in laminated paper*, by G. L. MCLEOD and THELMA L. WORKSMAN, TAPPI (in press); and *Improved map paper*, NBS Tech. News Bull. **42**: 148. 1958.

[3] *Preparation of fiber test sheets*, by M. B. SHAW, G. W. BICKING, and L. W. SNYDER, Paper Trade Journ. **90(16)**: *T.S.* 69. 1930.

the synthetic-fiber papers, in either black and white, or in the regular five-color lithographic process used for Army maps. The smoothness and opacity ratings of the synthetic fiber sheets are lower than those of regular map paper, but these are minor deficiencies which can be easily overcome. That the synthetic-fiber papers have less dry tensile strength than commercial map paper is attributed to the low fiber-to-fiber bonding in the synthetics. Dry tensile strength, however, is a relatively unimportant factor in papers used for military maps.

TABLE 1.—COMPARISON OF TEST RESULTS FOR HANDSHEETS FROM BLENDS OF 75 PERCENT SYNTHETIC FIBER AND 25 PERCENT CELLULOSE FIBER WITH 100 PERCENT CELLULOSE HANDSHEETS

Tests performed	Test results			
	50–50 cotton and linen waterleaf	75% nylon	75% polyacrylate	75% polyester
Basis weight (17 × 22–500), in pounds	23.8	34.6	30.2	31.9
Thickness, in inches	0.0054	0.0118	0.0059	0.0108
Expansivity for relative humidity change between 65 and 50%, in percent	...	0.25	0.037	0.014
Folding endurance, Schopper, double folds	Approx. 1200	100,000	4260	31,600
Bursting strength, points	46	122	86	76
Tensile strength, kg/15 mm:				
Dry	25.6	6.1	5.8	4.4
Wet	2.5	2.0	1.3	3.5
Tearing strength, in grams	156	864	323	590

TABLE 2.—TEST RESULTS OF MACHINE-MADE POLYESTER-RAG, NYLON-RAG, AND COMMERCIAL MAP PAPER

Tests performed	50:50 Polyester-rag	50:50 Nylon-rag	Commercial map paper	Federal specification requirements
Basis weight (17 × 22–500), in pounds	26.2	22.6	23.7	24 ± 5%
Expansivity for relative humidity change between 65 and 50%:				
Machine direction	0.059	0.196	0.071	0.075 max.
Cross direction	0.10	0.28	0.21	0.25 max.
Brightness, in percent	83.1	82.1	71.7	70.1
Acidity, pH, hot extraction	4.8	5.7	5.0	4.5
Smoothness (Bekk), in seconds	33	8	60	50–100
Water resistance, dry indicator, in seconds	94	77	70	55
Thickness, in inches	0.0052	0.0054	0.0041	0.0042 ± 0.0005
Folding endurance, Schopper, double folds:				
Machine direction	14,300	40,000	1410	1000
Cross direction	11,300	13,500	1300	1000
Bursting strength, in points:				
Dry	49	50	50	50
Wet	46	30	30	20
Tensile strength, dry, in kg./15 mm:				
Machine direction	7.5	6.5	11.8	11.0
Cross direction	5.2	4.5	6.8	6.0
Tensile strength, wet, in kg./15 mm:				
Machine direction	5.3	3.4	4.4	3.5
Cross direction	4.2	2.3	2.8	2.5
Tearing strength, in grams:				
Machine direction	151	168	85	95
Cross direction	141	108	94	95
Opacity, in percent	75.8	67.1	93.2	91.0

[a] All figures are minimum values unless otherwise designated.